Automatic Whiteboard Eraser Interfaced Using Assembly Language

by

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A Design Report Submitted to the School of Electrical Engineering, Electronics and Communications Engineering, and Computer Engineering in Fulfillment of the Requirements for the Degree

Bachelor of Science in Computer Engineering

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Approval Sheet

Mapua Institute of Technology
School of EE-ECE-CoE

This is to certify that we have supervised the preparation of and read the design report prepared by **Erika Grace G. Diamante, Katherine H. Flores, Emmanuel Jesus A. Garcia, and Lorenzo N. Raralio** entitled **Automatic Whiteboard Eraser Interfaced using Assembly Language** and that the said report has been submitted for final examination by the Oral Examination Committee.

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As members of the Oral Examination Committee, we certify that we have examined this design report, presented before the committee on **September 12, 2009,** and hereby recommended that it be accepted as fulfillment of the design requirement for the degree in **Bachelor of Science in Computer Engineering.**

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This design report is hereby approved and accepted by the School of Electrical Engineering, Electronics and Communications Engineering, and Computer Engineering as fulfillment of the design requirement for the degree in **Bachelor of Science in Computer Engineering.**

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ABSTRACT

The Automatic Whiteboard Eraser is a design project that operates through pc interfacing using parallel ports. Assembly language is used to program the parallel port to be able to manipulate the movement of the eraser. The parallel port was used so that the program would be able to interact with the circuitry fully. The design will erase the writings on the board without the user exerting so much effort, prevent straining oneself, and be able to reduce the time used. Electronics, Microprocessors, and Assembly Language are the essential courses used as basis for the design's internal structure. The mechanical aspect of the design is based on the idea of a sliding door. The Automatic Whiteboard Eraser's intended application is to erase the writings on the board which would consume less effort and time compared to manual erasing but still efficient. With the use of Assembly Language, the intended operation of the design could be achieved by a push of a button.

Keywords: Interface module, relay module, DC motors, parallel port, Automatic Whiteboard Eraser

Chapter 1

DESIGN BACKGROUND AND INTRODUCTION

This chapter shows a general overview of the design project. It gives the reader the background or basis of the problem to be reported. It is the section that states the purpose and goals of the study. In this chapter, the Automatic Whiteboard Eraser is introduced as a design project that automatically erases the contents of a whiteboard with only a push of a button. Such project would save time and effort compared to manual work.

Background

Erasing writings on whiteboards is tiresome. Having to erase all the writings manually from one end to the other end causes hassle and wastes too much energy on the part of the one using it. Lecturers would waste time and tend to get exhausted and would get sore muscles after doing the work.

One application, where the design originated, is a toy which erases whatever is written on the small board. The toy contains an inner black material surfaced with a thin cotton sheet and then topped with a plastic sheet. Any metallic pointed object can be used as a pen since the black material underneath the board will serve as the ink for the pen. Inside the toy, is a long thin plastic object, which is the eraser, attached to the controller. The automatic whiteboard eraser tends to have almost the same feature as the toy. However, it will be

used on full-sized boards which means, the design will only be applicable on whiteboards with no cuts in the middle.

The design's intended application is simply to erase whatever is written on the whiteboard without straining oneself.

The design would automate the erasing of whiteboard's contents. An eraser with the height of the writing surface of the board would be used. It will be attached to the board, and using the interface, the eraser will be moving on with a set direction. Assembly language will be used in creating the design's procedure.

The design will be composed of an interface/DB25 module, relay module, and the whiteboard. The input will come from a push button connected on the interface module.

Statement of the Problem

Manual erasing of the contents of whiteboards is tiring. Too much energy is wasted when doing such work when the lecturer could just have an automatic whiteboard eraser do the work so that he/she may be able to continue lecturing. A team of design enthusiasts are eager to improve this simple application from manual to automatic. Human application is still needed for the design project to work. The user needs to run a certain program and push the appropriate buttons to use the prototype. The idea of the design being automatic is that with only a push of a button, the eraser can move.

Objectives of the Design

The general objective of the design project is to improve manual application of doing work to automatic application.

The specific objectives are:

- To create a design that would be able to erase the writings on the whiteboard using PC interfacing.
- To save time and avoid straining oneself in erasing writings on whiteboards compared to manual operation but could still be effective in cleaning the board.
- To create a program that would manoeuvre the movement of the eraser.
- The user must be able to run the program to use the automatic eraser.
- To provide a mechanism in which with only a push of a button, the user could set the eraser to move and erase the contents of the board.
- To use the preferred material that could easily erase the writings on the board.

Significance and Impact of the Design

The Automatic Whiteboard Eraser will be useful to lecturers who often use whiteboards as medium in imparting knowledge to listeners. It will lessen the time and energy required to erase the board, especially for those who have very long lectures. It would be of great help for them since they would not be

wasting time in erasing the board, and they would have more time to spend in lecturing. Automation is very much of use in this age. As with the flow of the technology, the significance of carrying out the design is to provide a better quality of doing such work. Upgrading manual application of erasing to automatic application is in line with the trend of the modern era where simple manual applications are modified or upgraded to lessen the time used in doing the work. The operations that would be required to move the eraser through the board surface that could be implemented using sub-circuits were implemented using pc interfacing, thereby reducing the need for a bigger circuit.

The design's influence to society would be that project designers could make use of personal computers to integrate their innovations to limit the need to create hardware for their design. This in turn would lessen electronic waste brought upon the phasing-out or obsoletion of electronic devices. Simple applications can be automated to prevent straining of the arms and save time used in doing a particular task. It opens the path for using low-level language in interfacing, the advantage of such would be that being the one closest to computer language, it would be the fastest to execute.

Scope and Delimitations

Scope

Assembly language programming was used to manage the circuitry of the design.

The erasing material that was chosen was able to remove the writings on the whiteboard surface for a certain period.

The speed would be the only factor of the design that could be varied.

The delay of the DC motors could be modified through the assembly program.

A pair of relays is used for each motor to manipulate the direction of its rotation.

Parallel port was used for the interfacing of the hardware circuitry to the computer.

Delimitations

1. In using this design, the eraser should be attached to a board, and could only be reattached to similar sized boards.
2. Its application is limited to singular rectangular boards.
3. For those that used two boards, implementation of the design might damage the device since it was designed for use on single-pieced boards.
4. The design, making use of pc interfacing, could not be used during power interruptions.
5. The eraser only moves horizontally from left to right and vice versa.
6. The user will have to press the stop function before the eraser could reverse its movement for optimum performance.

7. The contact between the eraser and the writing surface would be manually adjusted.
8. The eraser, once worn out, is difficult to be replaced or adjusted due to the structure of the customized eraser holder.

Definition of Terms

1. Assembly – the name given to any low-level computer language that is tailored to the architecture of a specific microprocessor. Assembly languages are a more-readable shorthand form of binary code. *(Source: Abel, P. 2000. IBM PC Assembly Language and Programming, 5th ed. Prentice Hall PTR, NJ, USA)*

2. DC Motor – in this design, a dc motor will be used to enable the movement of the eraser once connected to the source. A DC motor is an electronic rotating machine energized by direct current and used to convert electric energy to mechanical energy. It consists of two basic parts: a fieldframe assembly and an armature assembly. *(Source: Anderson, B.M. 1975. Soldering and Welding. Drake Publishers, Inc., NY, USA)*

3. Interface – a system consisting of hardware, software, or both that allows two dissimilar components to interact. *(Source: Gadre, D.V. 1998. Programming the Parallel Port: Interfacing the PC for Data Acquisition and Process Control. R&D Books Miller Freeman, KS, USA)*

4. Module – subdivides a system into smaller parts which can be created independently and then used to drive multiple functionalities.
5. Parallel Interface – there are multiple lines connecting the I/O module and the peripheral, and multiple bits are transferred simultaneously, just as all bits of a word are transferred simultaneously over the data bus. *(Source: Stallings, W. July 2005. Computer Organization and Architecture, 7th ed. Prentice Hall, NJ, USA)*
6. Parallel port – refers to ports conforming to a specification (and later enhancements) for what was originally known as the parallel printer adapter. *(Source: Gadre, D.V. 1998. Programming the Parallel Port: Interfacing the PC for Data Acquisition and Process Control. R&D Books Miller Freeman, KS, USA)*
7. Printed Circuit Board (PCB) – a rigid or flexible board on which an electrical circuit is etched, and to which electronic components can be attached, eliminating the need for complex wiring. *(Sources: Clark, R.H. 1985. Handbook of Printed Circuits Manufacturing. Van Nostrand Reinhold, NY, USA; Coombs, C.F. 1979. Printed Circuits Handbook. McGraw-Hill Handbooks; Lindsey, D. 1982. The Design and Drafting of Printed Circuits revised edition. McGraw-Hill Higher Education)*
8. Relay – an electrically controlled switch that is used to open or close an electric circuit. The switch can be actuated by various means.

Electromechanical operation is the most common. *(Sources: Harper, C. 1977. Transistor and Integrated Electronics, 4th ed. McGraw-Hill, NY, USA)*

9. Secondary Research – the use of previously existing resources to meet your research goals. *(Source: Grossnickle, J., Raskin, O. April 2001. The Handbook of Online Marketing Research "Knowing Your Customer Using the Net". McGraw-Hill, NJ, USA)*
10. Soldering – method of joining metals by the application of heat, sometimes combined with pressure, with the use of a filler metal which is lead. *(Sources: Allen, B.M. 1975. Soldering and Welding. Drake Publishers, Inc., NY, USA; Self, C.R. 1979. Welding, Brazing, and Soldering)*
11. Transistor – a solid-state electronic component that is able to control a relatively large electrical current flowing between two regions of a semiconductor crystal by a very small current or voltage applied to intermediate region. *(Sources: Pollack, H. June 1980. Transistor Theory and Circuits Made Simple. McGraw-Hill, NJ, USA; Kiver, M.S. 1972. Transistor and Integrated Electronics, 4th ed. McGraw-Hill, NY, USA)*
12. User interface – a means of how people (the users) interact with a machine or computer. *(Source: Gadre, D.V. 1998. Programming the Parallel Port: Interfacing the PC for Data Acquisition and Process Control. R&D Books Miller Freeman, KS, USA)*

Chapter 2

REVIEW OF RELATED LITERATURE AND STUDIES

This chapter gives the contextual setting or frame of reference given in the previous chapter by means of including statements about the general aspects of the problem already researched by other designers. The purpose of this study is to develop a conceptual model that describes the relationship of other studies to the design project. Articles and previous design projects about the design's major components such as the use of assembly language, parallel ports, DC motors, and SPDT relays are essential in creating the Automatic Whiteboard Eraser.

Parallel Ports

According to a study entitled "Interfacing a Standard Parallel Port", the author stated that the parallel port is an elegant solution for interfacing a data acquisition device with a PC. Parallel ports refer to ports conforming to a specification, and later enhancements, for what was originally known as the printer port. The parallel port is divided into three parts—the data port, control port, and status port. The function to be used is highly dependent on the port being accessed, whether it would be output only or write only, input only or read only, and the bi-directional port which could read and write data on the ports.

The control port, which is the output only port, contains eight usable ports or 8 bits of data. The status port, which is the input only port, contains five usable ports or 5 bits of data. The control port contains four usable ports or 4 bits of data that could either be an input or an output data.

Pin	Register	Name	Direction In/Out
1	Control	nSTROBE	In/Out
2	Data	D0	Out
3	Data	D1	Out
4	Data	D2	Out
5	Data	D3	Out
6	Data	D4	Out
7	Data	D5	Out
8	Data	D6	Out
9	Data	D7	Out
10	Status	ACK – Acknowledgement	In
11	Status	Busy	In
12	Status	Paper Out	In
13	Status	Select	In
14	Control	Auto Feed	In/Out
15	Status	Error	In
16	Control	Reset/nINIT	In/Out
17	Control	Select Input	In/Out
18 – 25		Ground	Gnd

Table 2.1 Pin Connections of a Female DB25

As the table shows, each port is assigned to one of the three different parallel ports—control port, status port, and data port.

(Peacock, C., 1998)

PRINTER	DATA PORT	STATUS PORT	CONTROL PORT
LPT1	0x03BCH	0x03BDH	0x03BEH
LPT2	0x0378H	0x0379H	0x037Ah
LPT3	0x0278H	0x0279H	0x027AH

Table 2.2 Port Address for the three ports of the printer adapter

According to the study entitled, "Use of a PC Printer Port for Control and Data Acquisition", in interfacing the parallel port, one must first know the address on which to access the said port of the computer. The parallel port can usually be accessed through the data port address of 3BCH. This address value differs depending on the computer manufacturer and for the computer models. It is also dependent on the number of ports that are available in the computer. The other addresses that the parallel port could use would be at 378H or 278H. The status port address would be found at data port plus 1, and the control port address would be found at status port plus 1.

(Anderson, P.H., 1996)

Interfacing parallel ports using Assembly Language

The study entitled, "Use of a PC Printer Port for Control and Data Acquisition, shows a sample code of how to use a parallel port. However, the code used a different language.

It shows how to first locate the address used by the parallel port using the DOS command line then proceeds on how to access the ports through the address obtained in the DOS command line. Although the code was written in C

language, it still demonstrated the logic on how to access the address ports which a vital part of the design project. Certain lines of codes do give off hints regarding the equivalent block of codes in a different language.

This study relates how to access the port using reserved words and commands. Obtaining the expected function whether it would be to get data from the port or write data to the port, the key elements needed would be to know the equivalent command or reserved word to use and the address of the port that would be accessed. In the case of this study, the C language reserved words that were used were inport and outport.

In storing or passing data from the parallel port, it is very evident that the C language, being a high-level language, does not need any compensation or any alterations coming from the programmer since proper initialization of the variables used would be sufficient to get the exact value of the data.

(Anderson, P.H., 1996)

"Interfacing the IBM PC Parallel Printer Port" is a study that discusses the retrieving and sending data to and from the parallel port. According to this study, designers should take into account the registers to use and the number of bits the particular port is using.

When retrieving data from the status port, it should be taken into consideration the number of bits the status port is using. Since assembly language uses registers, the minimum number of bits that a register would be

holding is 8 bits or one byte. Status port uses only 5 bits of data. The bits used by the status ports are the five most significant bits of an 8-bit register and the excess bits would be of no significant value and are only treated as padded bits. *(Stewart, Z., 1994)*

DC Motors and SPDT Relays

In a study entitled “DC Motor reversing with relay”, tells about the control functions of relays which are the forward, stop, and reverse actions.

According to this study, the motor should not be switched from one direction to another unless it is stopped or set to a rest before. Putting a motor straight into into the opposite direction would be quite dangerous because when running a motor, it develops a back emf voltage which could add to the current flow in the opposite direction and probably cause arcing of the relay contacts.

When the forward button is pressed and released, the motor will run continuously in one direction. The Stop button must be used before pressing the reverse button. The Reverse button will cause the motor to run continuously in the opposite direction, or until the stop button is used.

(Collinson, A., 1995)

The motor reversing circuit for operating a bi-directional motor includes the standard H-bridge relay circuit which includes a first and a second relay. The first relay is capable of operatively engaging a first contact at a first time period

to provide a first connection of the motor to a power source to operate the motor in a first mode. The second relay is capable of operatively engaging a second contact at a second time period to provide a second connection of the motor to the power source to operate the motor in a second mode. The motor reversing circuit further includes a switch having at least one contact operatively engaging the first or second relay for effectuating the first or second connection, respectively. A third relay is operatively associated with the switch to provide a third connection of the motor to the power source as at least one contact operatively engages the first or second relay. The third connection is disconnected prior to disconnection of the first or second connection.

(Feil, P.G., Vaughn, T.H., 2000)

System and method for permanent magnet DC motor reversing, the system including multiple relays and a control switch electrically interconnected so as to provide an open circuit to the motor when the motor is off. In one embodiment, the system includes the first and second relays each including switch contacts and a coil for switching voltage to the motor. The system also includes a third relay including switch contacts and a coil for switching voltage to the motor, a control switch having multiple switch positions for selecting the rotational direction of the motor. The control switch, the motor, and the relays are electrically interconnected such that a first control switch position provides a first voltage to the motor, a second control switch position provides a second

voltage to the motor, the second voltage being opposite in polarity to the first voltage, and a third control switch position provides the open circuit to the motor.

(Niemela, P.W., 1994)

One design project called “INK-B-GONE”, a mechanical whiteboard eraser, used a DC motor to move its eraser to a specified direction. The device was required to demonstrate various degrees of freedom or mobility. The mechanical whiteboard eraser device needs to erase the whiteboard in the least possible amount of time possible. The target is to erase the entire board in 25 seconds. *(Cacace, A., Luna-Ramirez, E., Shafian, S., 2006)*

Chapter 3

DESIGN METHODOLOGY AND PROCEDURES

This chapter includes the collection of theories, ideas, or concepts related to the design project. It discusses the specific type of design methodology used to solve the design problem that includes the methods used to gather and analyze data that are essential to developing the project. Methods such as secondary and constructive research were done to implement the design project. This chapter also discusses the step-by-step procedure in creating the Automatic Whiteboard Eraser.

Design Methodology

The Automatic Whiteboard Eraser was designed after gathering sufficient information from different sources. Secondary research involves analysing the summary of previous studies, articles, and other existing research. This research was done to obtain information about the components that can be used in creating the design. This kind of research includes the summary, collection, or synthesis of existing researches or documents where significant data is collected. This research occurs when a certain project needs a summary of existing data. Data are obtained from secondary resources—and these secondary resources include previous research reports, magazines, journal contents, etc. As to this

design, there were useful components from numerous technical reports that can be used in creating the prototype.

Another method used is the constructive research. This type of research demands a form of validation that does not need to be quite as empirically based. Constructive research was done by setting objectives, identification of the process model; afterwards simulation, testing, and evaluation would then be implemented. Secondary research was used to supplement the methods applied using the constructive research.

Design Procedures

The Automatic Whiteboard Eraser makes use of a motor, particularly a DC motor that will be responsible in moving the eraser from one point to another. A relay module is used to power the eraser's motor. This module will be connected to another module containing the parallel port for the interface. Through PC interfacing, assembly language will be used in manipulating the movement of the eraser.

The project was designed using the concepts from books and articles as stated in the second chapter. One is the use of a motor to move a certain component to whatever position the user wants. This motor is one of the major components, which without it, there will be no essence of having an automatic eraser. There are two modules in this design project—one for the relay and the

other is for the interface. These circuits were designed using the concepts from Electronics, Microprocessors, and Assembly Language courses.

The relay module consists of the following components—relays, transistors, resistors, header connectors, and LEDs. The interface module makes use of header connectors, female connectors, tact switches, LEDs, and a female DB25 connector. Two data lines from the parallel port are connected to the two relays then connected to the DC motor and it will power up the automatic eraser. By applying the concepts from the three courses stated above, the internal structure of the design made.

Procedure for the relay and interface modules:

1. Create a circuit for the interface and the SPDT relay (see Appendix D) similar to Figures 3.7 and 3.8 with your choice of software.
2. Simulate the circuit. Make sure everything is connected properly. Then convert it to its PCB layout using PCB Wizard. (see Figures 3.11 and 3.12)
3. The PCB layout of the circuits will be embedded on the board. The board size must be appropriate for the size of the layout.
4. After transferring the layout of the circuit to the PCB, the board will be submerged to the developer and then to the Ferric Chloride solution.
5. Once the layout is visible, drill the points indicated in the layout where the components will be inserted.

6. Solder the components. Make sure that everything is connected. Do not leave any broken connections to prevent significant error in the output.

Procedure for the Whiteboard eraser:

Part 1: Setting up the frame of the whiteboard

2. Provide whiteboard with the size not exceeding 40” in height and 24’’ in width.
3. Create your desired style of the frame with stand. Make sure to consider how to attach the customized whiteboard eraser.
4. Provide the two 1m steel track, A9T Sliding System (see Appendix A), 1/8” x 1” x 1” angled and 1” wide counter trim aluminium bars, and screw. These steel tracks will be used as the sliding guide for the eraser.

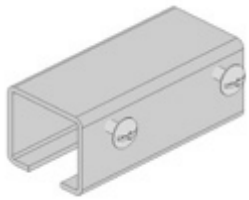


Figure 3.1 Steel track

5. Before starting any installation, make sure that the frame is sufficiently strong and rigid to support the steel track.
6. Wipe the inside of the steel track completely clean to sustain the smooth operation of the wheel carrier.

7. The frame has a width of 42 ½" and a height of 55". Measure 3" from the lower end of whiteboard then mark the sides of the frame. The marked area will be the steel track's position.
8. Since the steel track is a bit shorter for about 9 cm, provide counter trim and flat bars which could hold the steel track and be able to attach it to the sides of the frame. Make sure that the steel track is fixed on the frame.
9. Screw the track stops on both ends of the steel track.
10. To install another steel track on top of the frame, measure 2 ½" from the upper end of the whiteboard.
11. Provide angled aluminium bars to hold the steel track since the stand only measures 55" high. There must be enough space to put the A9T wheel carriers (rollers) and to install the customized eraser. Make sure that these angled bars are strong enough to hold the steel track.

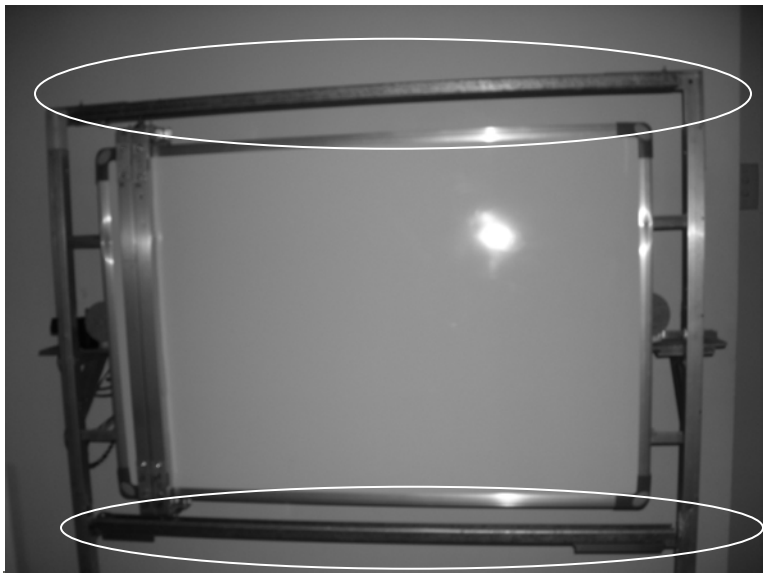


Figure 3.2 Installed steel bars

Part 2: Setting up the DC motors

12. Prepare the two DC motors, plywood, flat aluminium bars, screw, and rivets.
13. Determine the center of the length of the board on both sides.
14. Create a stand for the DC motors, one on each side of the board, by combining the aluminium bars to look like the figure below.

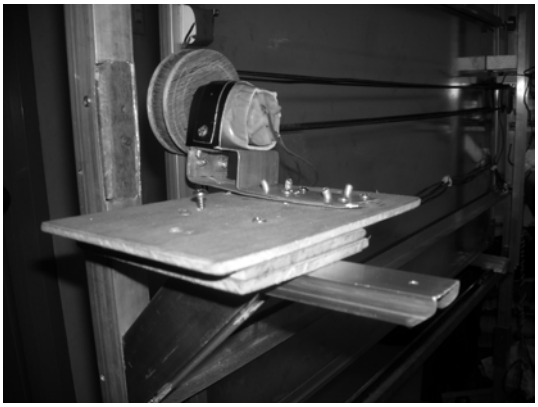


Figure 3.3 DC motor stand

15. Prepare the conveyor belt. Insert the belt to the DC motors and stretch it to its maximum.
16. Position the DC motors to the center of the length of the board considering how long the conveyor belt reaches its maximum.
17. Attach the motors to the stand.

Part 3: Creating the customized whiteboard eraser

1. Prepare the eraser to be used, 1” wide counter trim and flat aluminium bars, Mighty Bond, screw, and screwdriver.
2. Measure the writing surface vertically. The acquired dimension will be used to prepare the eraser holder. The eraser holder will be using a 1” wide counter trim aluminium bar. Make four of these bars.

Note: Two counter trim bars will be used as the eraser holder and the other two will be used as support at the back of the board which will be attached to the conveyor belt.

3. Using the 1” wide counter trim and flat aluminium bars, create a connection between the eraser holder and the support which will later be used to connect to the wheel carrier on the steel bar. See figures below.

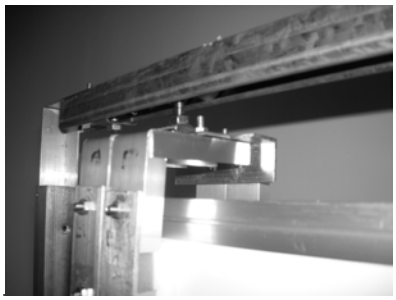


Figure 3.4 (a)

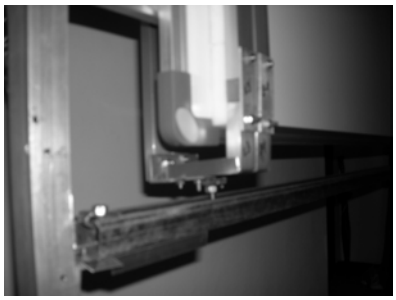


Figure 3.4 (b)

Figure 3.5 Customized whiteboard eraser

Part 4: Attaching the customized eraser to the conveyor belt

1. Prepare at least 2 ½” of a 2” wide counter trim aluminium bar.
2. Saw the center part of the counter trim at least a half inch and fold it.

3. Screw the sides of the 2” wide counter trim bar to the sides of the support.
4. Drill for holes on the 2” wide counter trim bar where the conveyor belt makes contact. These holes will be used to tie the belt onto the bar.

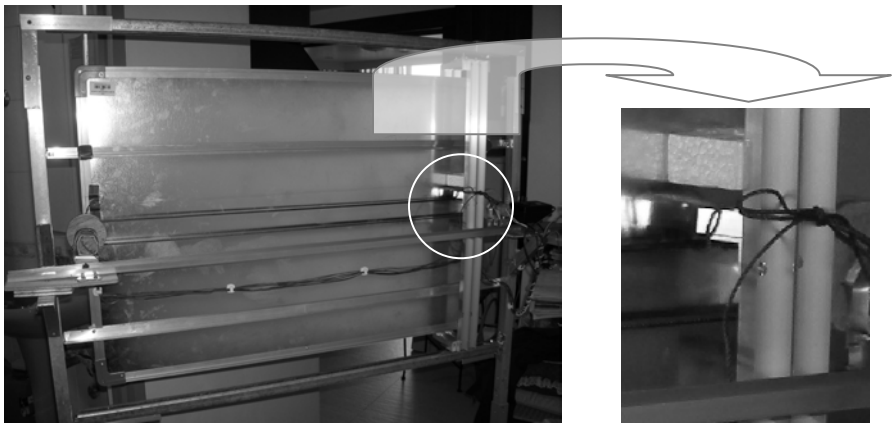


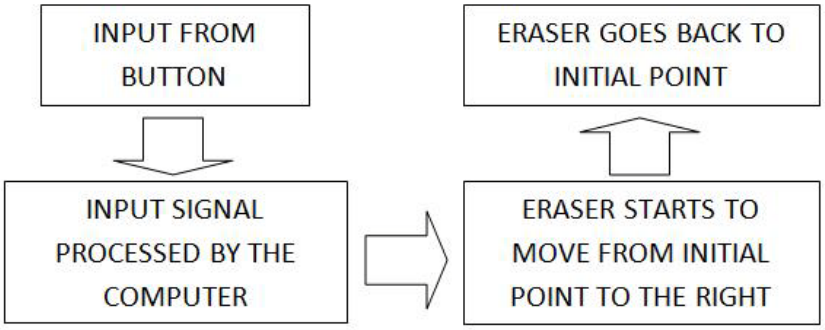
Figure 3.6 Two 1” wide counter trim bars attached to the conveyor belt

Part 5: Attaching the limit switches

1. Test the movement of the eraser by means of attaching the motor to the adapter and connect it to the 220V socket. With this, analyze the movement of the eraser from left (initial point) to the right.
2. Once the eraser moves to the right side of the board, determine an area where you can put the limit switch. This limit switch (see Appendix B) triggers the movement of the eraser, from the right side of the board to its initial point.

HARDWARE DESIGN

1. Block Diagram


INPUT FROM BUTTON
INPUT SIGNAL PROCESSED BY THE COMPUTER
ERASER STARTS TO MOVE FROM INITIAL POINT TO THE RIGHT
ERASER GOES BACK TO INITIAL POINT

This is the block diagram of the whole design project. The movement of the eraser is triggered once the user presses the button. It sends a signal to the computer and processes it then it could move. There are also other controls on how to manipulate the movement of the eraser. These are the reverse and stop functions.

2. Schematic Diagram and PCB Layout

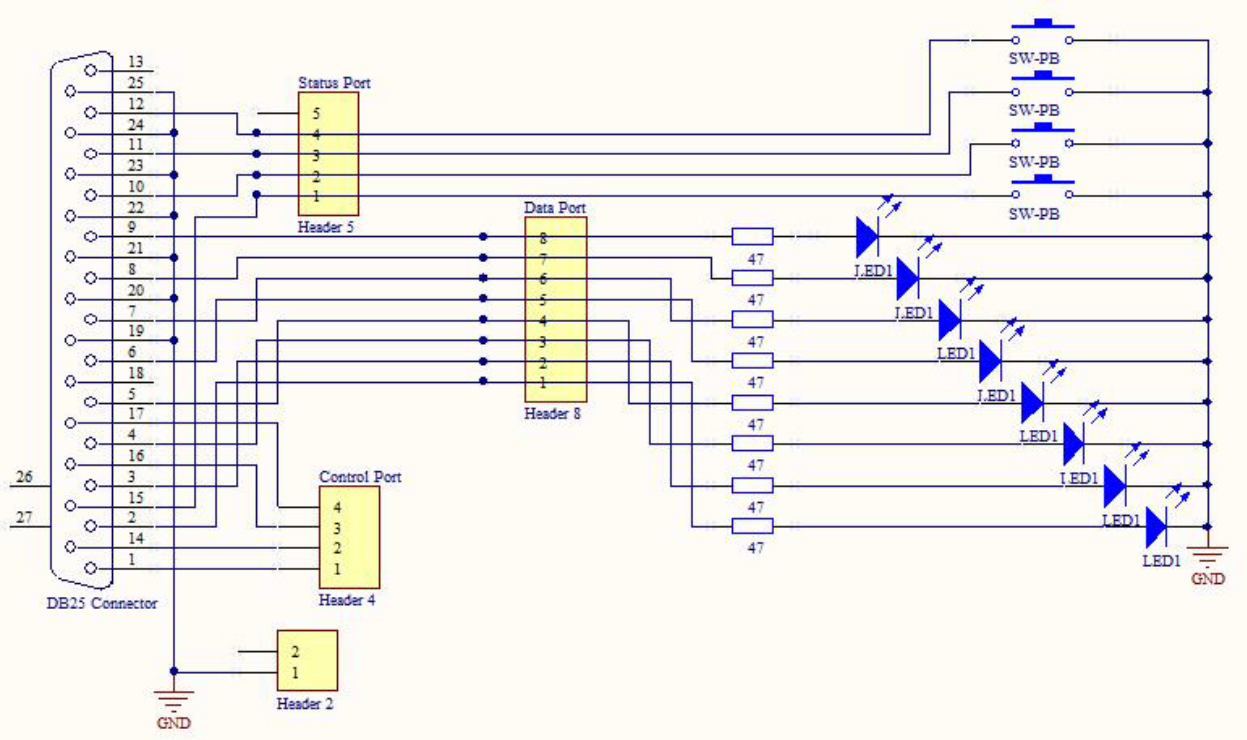


Figure 3.7 Interface/DB25 Module

This is the schematic diagram for the interface module. An assembly program will be responsible on how to manipulate the design project. As you can see, only three pins are used in the status ports. The three pins are for three functions: start, reverse, and stop functions. The data ports will indicate the value of these three functions as indicated in the assembly program (see Interface Program). The input comes from the status ports, which sends the signal to the computer, and then proceeds to the data port to output the values on the respective LEDs.

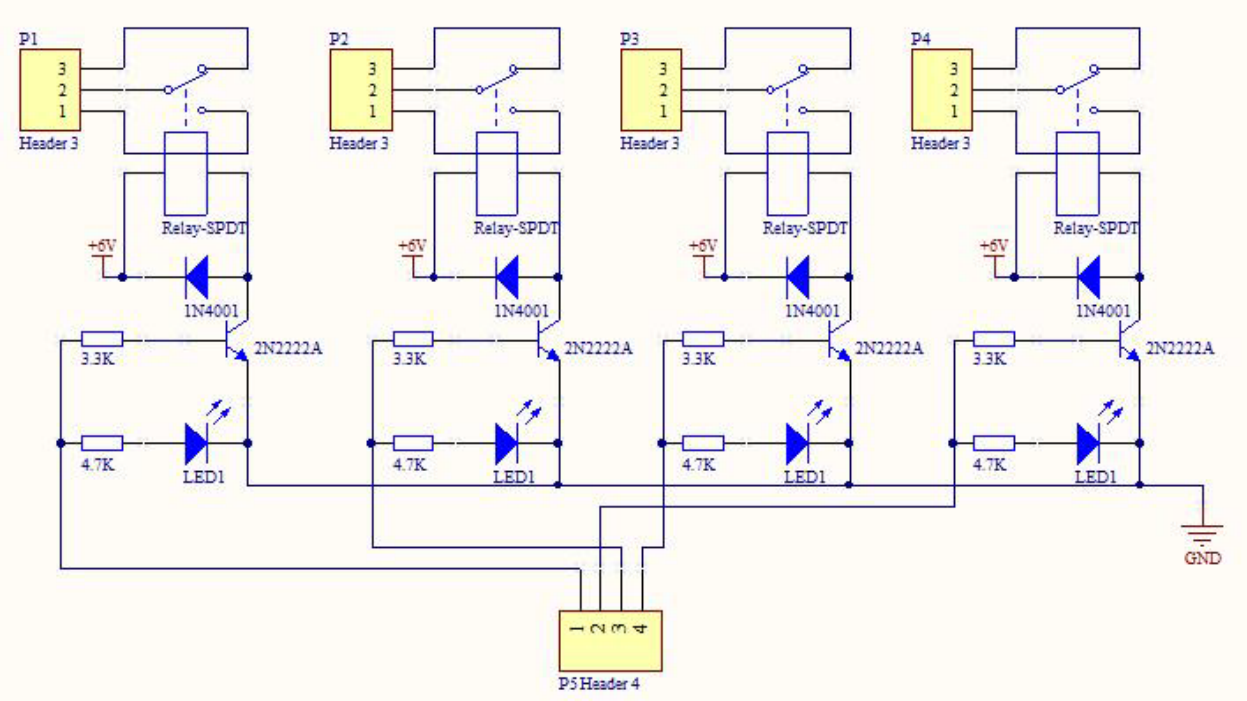


Figure 3.8 Relay Module

This is the schematic diagram of the relay module. The input for these relays comes from the data ports as shown in Figure 3.9. The input coming from the data port in the interface module is connected to the resistor then all the way up to trigger the switch in the relay. The status port as shown in Figure 3.7 is the input which will contains what operation the user desires. In this circuit, there are four SPDT relays used since the design project makes use of two DC motors. The relays on this circuit control the forward, reverse, and stop actions. Switching a device such a DC motor which draws more current than is provided by an output switch or component needs a relay. There are diodes connected to each relay. These diodes are used across the coil to provide a path for current when current path to the relay is interrupted. The diode protects the relay contacts that may be sensitive to voltage spikes.

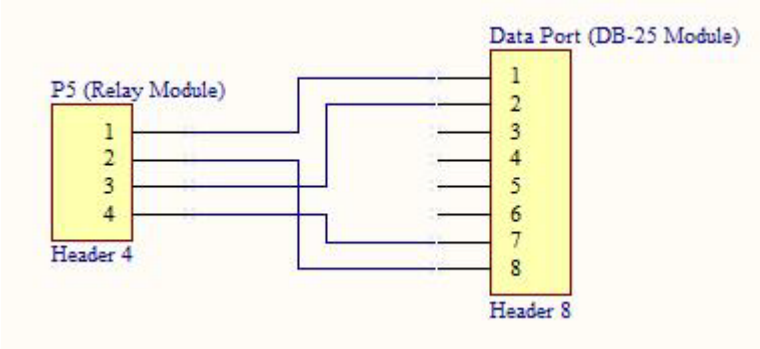


Figure 3.9 Relay Module to Interface/DB25 Module

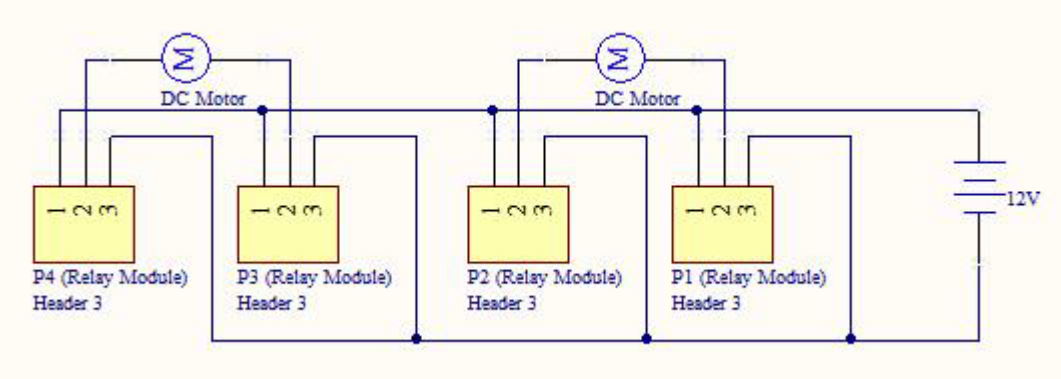


Figure 3.10 Relay Module to DC Motor

This figure shows the connection of the header connections in the relay to the DC motors. Two DC motors are used—one on each side of the whiteboard. This will help to fully activate the movement of the eraser. The input from the data port will go through the series of components in the relay module and will have an output on the Pin 2 on each header connections shown above. The output will trigger the motor to move. Pins 1 and 3 will be connected to the adapter that will supply power on the relays to move the motor.

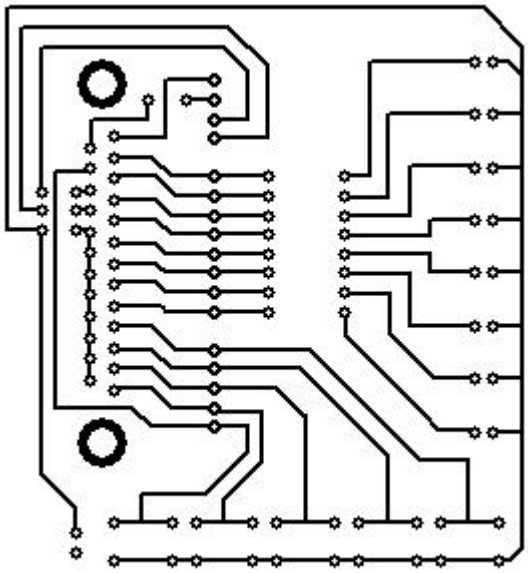


Figure 3.11 PCB Layout of the Interface/DB25 Module

This figure is the PCB layout of the interface module done using the PCB Wizard software, as shown in the figure below.

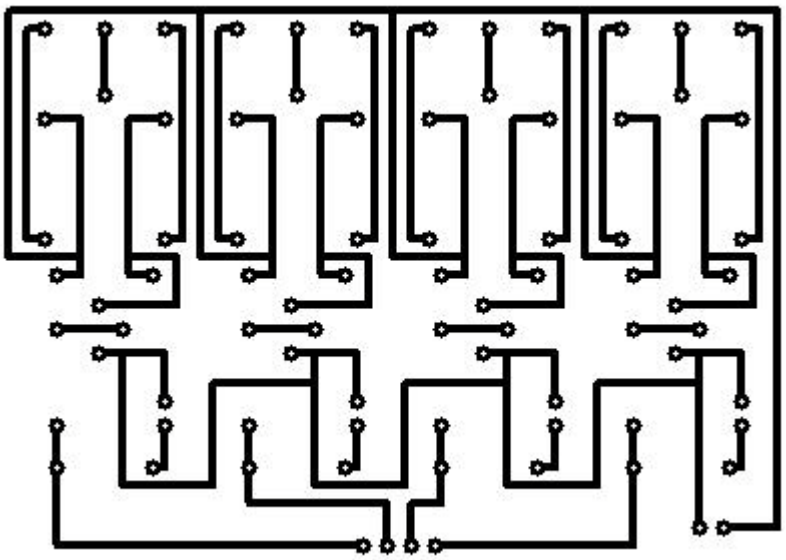


Figure 3.12 PCB Layout of the Relay Module

3. List of Materials

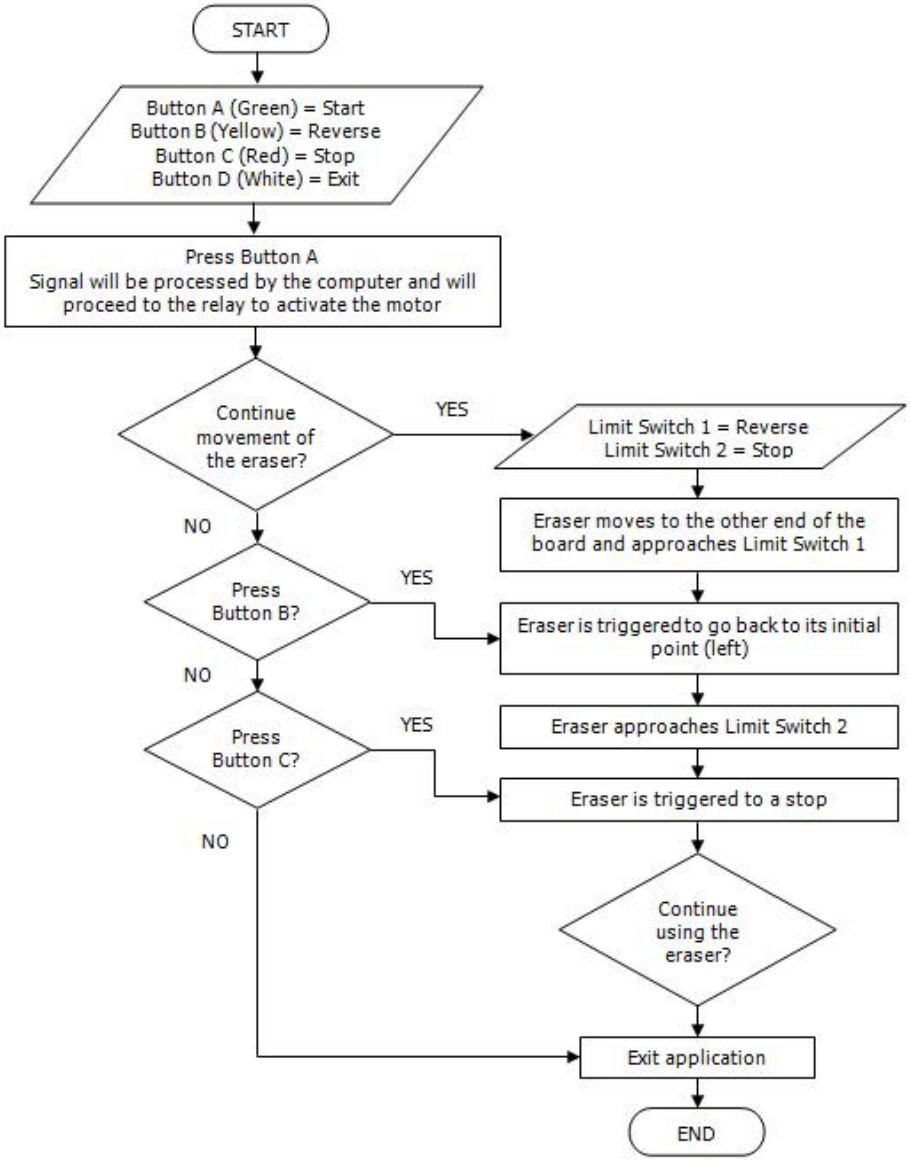
Component	Quantity	Price
12V SPDT Relay	4 pcs.	P 50.00/pc
3.3kΩ Resistor	4 pcs.	P 0.25/pc
4.7kΩ Resistor	4 pcs.	P 0.25/pc
470kΩ Resistor	8 pcs.	P 1.50/pc
2N222A NPN Transistor (see Appendix C)	4 pcs.	P 3.00/pc
40-pin Header connector	2 pcs.	P 16.00/pc
1N4001 Diode (see Appendix E)	4 pcs.	P 1.00/pc
#22 Stranded wire (red)	20 ft.	P 4.00/ft
#22 Stranded wire (black)	20 ft.	P 4.00/ft
5mm LEDs	12 pcs.	P 2.00/pc
4x6 Photo-etch PCB	2 pcs.	P 90.00/pc
12 DC Adapter	1 pc.	P 168.00/pc
Female DB25 Adapter	1 pc	P 30.00/pc
Parallel Port connector (male)	1 pc.	P 50.00/pc
Tact Switch	4 pcs.	P 7.00/pc
Push Button	4 pcs.	P 14.50/pc
6-pin Female connector	2 pcs.	P 12.00/pc
4-pin Female connector	2 pcs.	P 8.00/pc
2-pin Female connector	4 pcs.	P 4.00/pc
6-pin Male connector	1 pc.	P 9.00/pc
4-pin Male connector	1 pc.	P 7.50/pc
2-pin Male connector	2 pcs.	P 5.00/pc
35” x 24” whiteboard	1 pc.	P 570.00
12V DC Motor	2 pcs.	P 385/pc
Nylon Cord	2 ft.	P 2.50/ft
Custom Gear	2 pcs.	P 10.00/pc
Conveyor belt (rubber)	1 pc.	P 350.00/pc
Limit Switch (roller)	2 pcs.	P 30.00/pc
Centor A9T Sliding System	1 pc.	P 1,999.75
1m steel track (see Figure 3.1)	2 pcs.	P 350.00/pc
1/8” x 1” x 1” angled aluminium bar	3 ft.	P 50.00/ft
1” wide counter trim aluminium bar	3 ft.	P 10.00/ft
1” wide flat aluminium bar	16 ft.	P 268.00

1” x 1” square hollow aluminium bar	15 ft.	P 20.00/ft
Rollers	4 pcs.	P 35.00/pc
Whiteboard/chalkboard eraser	5 pcs.	P 21.00/pc
Cloth	12 pcs.	P 50.00
3M Erasing Pad	6 pcs.	P 59.75/pc

These are the materials used for the relay module, interface module, and the whiteboard frame. All four pieces of relays are to be used since the design makes use of two DC motors. The main components of the interface module are the DB25 connector and header connectors. These header connectors will serve as the data, control and status ports of the DB25 connector. The status port, which is connected to the tact switches, will be the inputs for the prototype. These contain the different functions of the Automatic Whiteboard Eraser. Two DC motors will be used to force the movement of the eraser. With the two DC motors, the eraser could easily be moved from its initial point to the left and versa.

SOFTWARE DESIGN

1. System Flowchart


START
Button A (Green) = Start
Button B (Yellow) = Reverse
Button C (Red) = Stop
Button D (White) = Exit
Press Button A
Signal will be processed by the computer and will proceed to the relay to activate the motor
Continue movement of the eraser?
YES
Limit Switch 1 = Reverse
Limit Switch 2 = Stop
NO
Eraser moves to the other end of the board and approaches Limit Switch 1
Press Button B?
YES
Eraser is triggered to go back to its initial point (left)
NO
Press Button C?
YES
Eraser approaches Limit Switch 2
Eraser is triggered to a stop
NO
Continue using the eraser?
Exit application
END

The figure shows the detailed operation of the design project. The user will have to press the push button indicating the start function to begin the eraser's operation. He could either let it continue or stop its movement. There are also limit switches that have the same operations as the other two—stopping and reversing the eraser's movement. If the user lets the eraser move, it could

approach the limit switch and reverse its movement. The user could also stop the movement in the middle of its operation or it could reverse it immediately.

2. Interface Program

```
.model small
.stack 200h
.code

BEGIN:
      MOV               AL,00H
      MOV               DX,03BCH
      OUT               DX,AL
      MOV               CX,0000H
      MOV               BX,0000H
STARTO:
      MOV               AL,00H
      MOV               DX,03BDH
      IN                AL,DX
      MOV               AL,AL
      XOR               AL,01111111b
      CMP               AL,00001000b
      JE                OUTLEFT
      CMP               AL,00010000b
      JE                OUTRIGHT
      CMP               AL,00100000b
      JE                OUTMID
      CMP               AL,10000000b
```

```
        JE              EXIT
OUTTER:
        CMP             BH,40H
        JE              OUTTER3
        MOV             AL,00111000b
        MOV             DX,03BCH
        OUT             DX,AL
        ADD             BH,01H
        JMP             OUTTER
OUTTER3:
        CMP             BL,01000001b
        JE              OUTRIGHTA1
        CMP             BL,10000010b
        JE              OUTLEFTA1
        JMP             OUTTER2
OUTLEFTA1:
        MOV             AL, BL
        JMP             OUTTER2
OUTRIGHTA1:
        MOV             AL,BL
OUTTER2:
        CALL            DELAY
        MOV             AL,BL
        MOV             DX,03BCH
        OUT             DX,AL
        JMP             STARTO
EXIT:
        MOV             AX,0000H
        MOV             DX,03BCH
```

```
        OUT             DX,AL
        MOV             AL,00000000b
        MOV             DX,03BCH
        MOV             AX,4C00h
        INT             21h
OUTRIGHT:
        MOV             BX,00H
        MOV             AL,01000001b
        MOV             BL,AL
        JMP             OUTTER
OUTLEFT:
        MOV             BX,00H
        MOV             AL,10000010b
        MOV             BL,AL
        JMP             OUTTER
OUTMID:
        MOV             BH,40H
        MOV             AL,00111000b
        MOV             BL,AL
        JMP             OUTTER2
DELAY:
        MOV             CX,0480H
DELAY2:
        PUSH            CX
        MOV             CX,0FFFH
DELAY3:
        NOP
        NOP
        NOP
```

```
        NOP
        NOP
        LOOP            DELAY3
        POP             CX
        LOOP            DELAY2
        RET

END BEGIN
```

Chapter 4

TESTING, PRESENTATION, AND INTERPRETATION OF DATA

This chapter involves different tests conducted that complied with the objectives stated in the first chapter. These tests were conducted to determine the functionality and the quality of the created design project with respect to the context in which it is intended to operate. Results of these tests were interpreted and analyzed to prove the functionality of the prototype.

Part 1: Testing the Interface Module

The interface module was tested if the assembly program would run perfectly. The LED indicator in the interface module must display the specified values for every operation. In this test, the db25 connector was connected to the printer port of the CPU through the parallel cord. The command prompt was opened, locate and run the design2.exe. Same procedure was done to the remaining tests. (See Appendix G)

Note: value 1 = on, value 0 = off

Operation 1: *Starting the movement of the eraser from the initial point*

Input: First button (Green)

Value specified: 10000010

The programs worked by first initiating a stop signal having a similar value with the red button (0011100). After the delay, it proceeded to the required value that would move the eraser.

Output in the interface module: **00111000→10000010**

Operation 2: *Reversing the movement of the eraser*

Input: Second button (Yellow)

Value specified: 01000001

For the reverse mode, same concept as to the starting movement of the eraser was done except for the value specified.

Output in the interface module: **00111000 → 01000001**

Operation 3: *Stopping the eraser*

Input: Third button (Red)

Value specified: 00011000

Output in the interface module: **00111000**

Operation of Limit Switch 1: *Reversing the movement of the eraser*

Input: Limit Switch 1 (Right)

Value specified: 01000010

Output in the interface module: **00111000 → 01000001**

This operation is the same as the yellow button.

Operation of Limit Switch 2: *Stopping the eraser*

Input: Limit Switch 2 (Left)

Value specified: 00111000

Output in the interface module: **00111000**

In this test, the designers were able to manipulate the values to be outputted by the interface module. According to the data acquired, the output corresponds to the specified value for the designated operations. These values represent the operation of the automatic eraser. The results of the limit switches are the same as those on the second and third buttons for they have the same operations.

Part 2: Movement of the DC motors

This test determined if the relay circuit complied with the program created.

Component	Function	
Green button	Start (left to right)	√
Yellow button / Limit Switch 1 (Right)	Reverse (right to left)	√
Red button / Limit Switch 2 (Left)	Stop	√

Table 4.1 Movement of the DC Motors

The data shows that the components complied with the program. The motors moved depending on which component was pressed.

Part 3: Manual and Automatic Erasing

In this test, the designers determined how much time was used in erasing a 35" x 24" whiteboard, both manually and automatically. In manual erasing, three kinds of erasers were used for testing to determine which among them was the best material for the design project. After gathering the results, the appropriate eraser was tested again for automatic erasing to determine how many rounds were needed to erase the contents of the board.

Note:

4. This test was done without replacing the material used or cleaning it during the test.
5. 1 round = the movement of the eraser from left to right and back to its initial point (left)

Manual Erasing

Material: Whiteboard/Chalkboard Eraser	
Trial	**Time (sec)**
1	13.584
2	11.993
3	16.152
4	21.064
5	16.671
6	15.456
7	16.753
8	18.479
9	27.323

10	23.840
Average	**18.1585**

Table 4.2 Time consumed in using Whiteboard/Chalkboard Eraser

Computation:

Average = (Trial 1 + ... + Trial 10) / 10

= (13.584 + 11.993 + 16.152 + 21.064 + 16.671 + 15.456 + 16.753 + 18.479 + 27.323 + 23.840) / 10

Average = 18.1585 seconds

The whiteboard/chalkboard eraser left residue at trials 8-9. At trial 10, during the operation, there were marker stains that could be seen which resulted to a longer time of erasing the contents of the board. The material did not totally absorb the marker stains.

Material: Cloth	
Trial	**Time (sec)**
1	31.784
2	22.464
3	33.416
4	28.361
5	31.936
Average	**19.5922**

Table 4.3 Time consumed in using cloth

Computation:

Average = (Trial 1 + Trial 2 + Trial 3 + Trial 4 + Trial 5) / 5

= (31.784 + 22.464 + 33.416 + 28.361 + 31.936) / 5

Average = 19.5922 seconds

The cloth took more time to absorb all the marker stains. After trial 5, the cloth could not be used to erase the contents of the board anymore. The designers decided not to continue the test since it would only leave the board messy and would take time to erase it clean.

Material: 3M Erasing Pad	
Trial	**Time (sec)**
1	24.184
2	21.122
3	25.808
4	11.016
5	18.805
6	10.296
7	13.472
8	11.863
9	13.216
10	12.976
Average (t_{ave1})	**16.2758**

Table 4.4 Time consumed in using 3M Erasing Pad

Computation:

Average = (Trial 1 + ... + Trial 10) / 10

= (24.184 + 21.122 + 25.808 + 11.016 + 18.805 + 10.296 + 13.472

11.863 + 13.216 + 12.976) / 10

Average = 16.2758 seconds

This material absorbed more stains compared to the other two. Based on the average time it consumed from erasing the writings of the board, it is the most appropriate material to be used in the design project.

Automatic Erasing

Material: 3M Erasing Pad		
Trial	**Rounds**	**Time (sec)**
1	2	26.580
2	3	28.616
3	3	56.249
4	2	45.016
5	2	24.151
6	1	11.015
7	2	24.647
8	2	33.801
9	1	19.929
10	1	20.808
11	1	38.400
12	1	31.920
Average		**30.0943**

Table 4.5 Time consumed and number of rounds using 3M Erasing Pad

Computation:

Average = (Trial 1 + ... + Trial 12) / 12

= (26.580 + 28.616 + 56.249 + 45.016 + 24.151 + 11.015 + 24.647

33.801 + 19.929 + 20.808 + 38.400 + 31.920) / 12

Average = 30.0943 seconds

After trial 10, the automatic eraser had difficulty in moving due to the state of the eraser used. With the results, the designers concluded that the operation of the Automatic Whiteboard Eraser is highly dependent on the volume of the writings and the state of the 3M Erasing Pad. The 3M Erasing Pad could absorb marker stains more effectively than the other two kinds of eraser as concluded before. However, if it is used frequently, the material is worn out and it will affect the movement of the whole eraser.

Comparing the speed of manual (S_1) and automatic erasing (S_2) using 3M Erasing Pad:

Distance (d) = length of the whiteboard – width of the eraser – space occupied by the DC motors on both sides

= 35" – 2" – 1"

Distance (d_1) = 32" = 0.8128 meters → manual erasing

Distance (d_2) = 0.8128 meters x 2 (average rounds = 1.9 ~ 2)

= 1.6256 meters → automatic erasing

t_{ave1} = 16.2758 sec

t_{ave2} = 29.0812 sec (average time for 10 trials only)

For manual erasing:

$S_1 = d_1/t_{ave1}$

= 0.8128 meters / 16.2758 sec

S_1 = <u>0.0499 m/s</u>

For automatic erasing:

$S_2 = d_2/t_{ave2}$

= 1.6256 meters / 29.0812 sec

S_2 = <u>0.0559 m/s</u>

In this computation, manual erasing is faster than automatic erasing considering the distances and the time consumed to erase the contents of the board. This test shows that manual erasing is faster than automatic erasing. However, the speed of the design project is a minor factor to be considered. The <u>time consumed by the user to push the buttons</u> to use the automatic whiteboard eraser, which takes less than 2 seconds, is the important factor to be considered in this design project. The user does not have to waste time and effort in doing manual work. The automatic whiteboard eraser will do the erasing job while the user can continue his/her work.

Part 4: <u>Determining the appropriate size of the whiteboard</u>

The designers previously used larger whiteboard with dimensions of 46" x 24" with a larger frame with dimensions of 61" x 48 ½". However, numerous problems were encountered. First, transporting the prototype was a nuisance since it could only fit in a van. Second, not all the areas of the whiteboard could be erased—considering the position of the DC motors and the length of the previous conveyor belt. There was so much space wasted on the sides of the board that is almost 5". In order to lessen these problems, the 46" x 24" board

was reduced to 35” x 24” at the same time reducing the size of the frame to 55” x 42 ½”.

The area of the board which could be erased is dependent on the length of the conveyor belt. Searching for the exact size of the conveyor belt is not easy. The expected size of the belt is 42” so that all areas of the board could be erased. However, there was no available conveyor belt with that size. A shorter size of the conveyor belt was used but still it is enough for the gear to handle and it is better than a longer one. It is easier to reduce the distance between the DC motors to comply with the shorter belt than to extend the distance to use the longer belt.

Chapter 5

CONCLUSION AND RECOMMENDATION

This chapter shows the overall conclusion of the design project with respect to the objectives stated on the first chapter. The Automatic Whiteboard Eraser complied with the specified objectives addressed in the first chapter. After the conducted tests, the designers have come up with some recommendations to improve the prototype. These recommendations address the delimitations stated in the first chapter.

Conclusion

The Automatic Whiteboard Eraser is a design project created through PC interfacing using assembly program. This assembly program, based on the test results, was able to manipulate the movement of the prototype. The values for each function of the prototype complies with the values specified in the program thus sending signal to the relays and activate the DC motors. The inputs for the prototype are connected to the push buttons which contain the different functions. With this, the user would only press these buttons to activate the prototype. Among the three materials used as eraser, 3M Erasing Pad proved to be a better eraser used for the prototype. Based on the results, the material could absorb more marker stains compared to the other materials. However, if it is used nonstop, it will be damaged and slows the performance of the prototype.

The Automatic Whiteboard Eraser erases the contents of the board without the user exerting much effort and saves time. After testing the prototype's performance, it is determined that the speed of doing manual erasing is faster than automatic erasing. However, this could not be considered as a major factor. The prototype is not concerned on the time consumed in erasing a 35" x 24" whiteboard. Instead, it is concerned on the time consumed by the user to push the button to activate the prototype. The user does not have to waste so much time and effort to do the job. The Automatic Whiteboard Eraser did the work while the user can do something else.

Recommendation

Based on the tests performed, the designers recommend the following:

1. Research further for other possible materials that have a longer lifespan in comparison with the one used in this design project.
2. Other designers may provide additional DC motors for the prototype to obtain a better performance. They may research for other components to smoothen the eraser's operation.
3. The material to be used as eraser would have fewer divisions to lessen the blind spots that the current design presents.
4. Since this design project is created using a frame, other designers should also look for other ways to apply the design to different types of whiteboard, like those fixated on the wall.

5. The eraser holder should be easier to access for eraser refills.
6. With regards to software, programmers could also develop an autorun file so that it will be easier to run the program or even make it as a background service.

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APPENDICES

APPENDIX A: CENTOR ARCHITECTURAL A9T SLIDING SYSTEM

APPENDIX B: LIMIT SWITCH (HINGE ROLLER LEVER) DATASHEET

APPENDIX C: 2N2222A NPN TRANSISTOR DATASHEET

APPENDIX D: SRUDH-SS-112D1 SPDT RELAY DATASHEET

APPENDIX E: 1N4001 DIODE DATASHEET

APPENDIX F: PARALLEL PORT

APPENDIX G: AUTOMATIC WHITEBOARD ERASER QUICK USER'S GUIDE

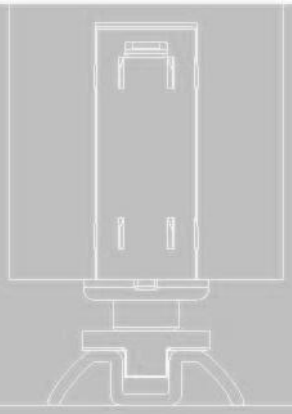
APPENDIX A

CENTOR ARCHITECTURAL A9T SLIDING SYSTEM

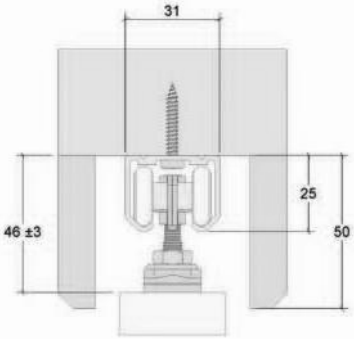
A9T: ARCHITECTURAL DETAIL

Downloadable DXF or DWG files ready for use in your own documentation are a convenient resource for architects and specifiers wishing to use Centor systems.

A9T DXF or DWG files can be downloaded from www.centor.com.au/au/a9t_cad.html

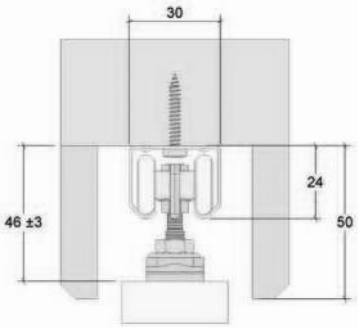


ALUMINIUM TRACK



9F-001.DXF

STEEL TRACK



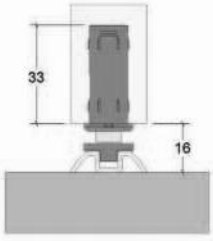
9F-002.DXF

2 versions of carrier available

94CCSM Stainless brackets.
Plated bearings.

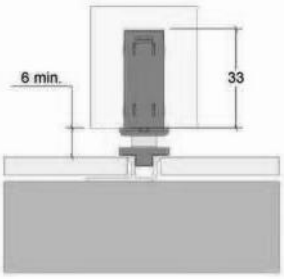
94CCSS Stainless brackets.
Stainless bearings.

9GC FLOOR CHANNEL ON CONCRETE, CARPET OR TIMBER



9F-003.DXF

MWT4CA FLOOR GUIDE IN TILE



9F-004.DXF

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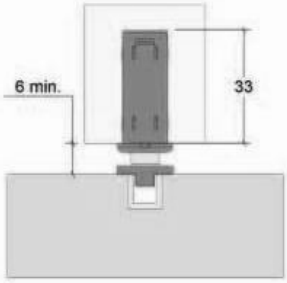
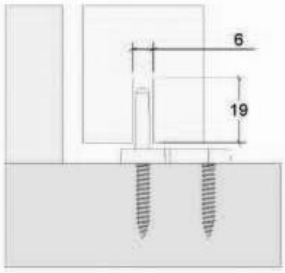
9FCA FLOOR GUIDE IN TIMBER



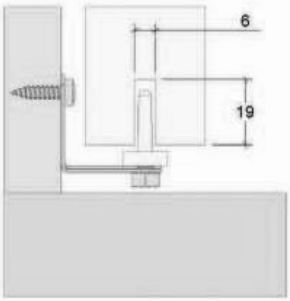
9F-005.DXF

1G GROOVE GUIDE ON TIMBER FLOOR



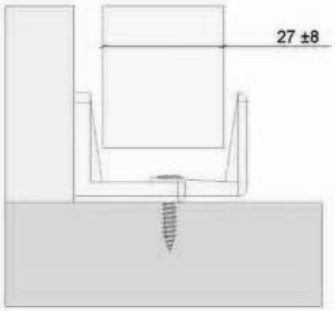
9F-006.DXF

1GW GROOVE GUIDE ON WALL



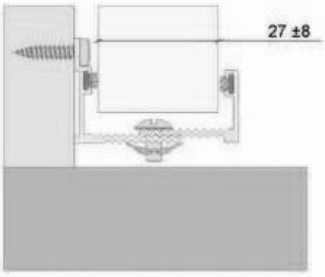
9F-007.DXF

1EG EXPANDING GUIDE ON TIMBER FLOOR



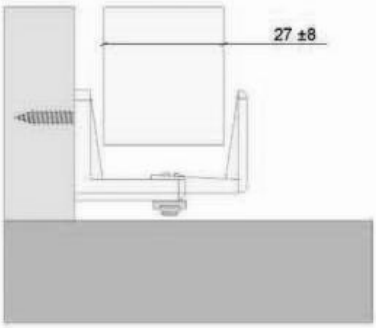
9F-008.DXF

1EGA EXPANDING GUIDE ON WALL



9F-009.DXF

1EG EXPANDING GUIDE ON WALL



9F-010.DXF

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A9T: COMPONENT SELECTION

A9T is specified with 6 separate component groups. Components are required from each group to build an A9T sliding door system except when indicated otherwise.

1. **Track** – choose material, surface finish and size required to suit opening
2. **Carriers** – choose material and number required to suit panel layout
3. **Guides** – choose guiding method and number required to suit panel layout
4. **Channel*** – choose fixing type, surface finish and size required to suit opening
5. **Accessories** – choose items which best suit opening and door panel requirements

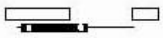
*Channels are an optional item

SETS SELECTION

The A9T sliding door track system is also available as complete sets.

To specify a complete set, simply choose the set corresponding to the desired panel width. The set is supplied standard with the 94CCSM 4 wheel carrier with stainless componentry and plated bearings, together with track stops and the 1G moulded nylon guide. The track is supplied in mill finished aluminium in two alternative lengths and is easily cut to size with a hacksaw. If desired, the track can be anodised or powdercoated to suit. The track length should be twice the width of the intended panel.

To specify the A9T as individual parts, see "Component Selection" section below.

PART	SELECT SET	PRODUCT CODE	SET DESCRIPTION
	up to 1000mm door	9FSA2	2000mm track set for single door containing: 1 x 9TA20 aluminium track 2 x 94CCSM carriers 1 x 1G guides 2 x 9TS stops 1 x screw pack
	up to 1500mm door	9FSA3	3000mm track set for single door containing: 1 x 9TA30 aluminium track 2 x 94CCSM carriers 1 x 1G guides 2 x 9TS stops 1 x screw pack

CARRIERS

PART	SELECT WEIGHT	PRODUCT CODE	PART DESCRIPTION
	60kg	94CCSM	4 wheel carrier, stainless steel & mild steel bogey
	60kg	94CCSS	4 wheel carrier, stainless steel with stainless steel bogey

pt 084

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GUIDES

PART	SELECT STYLE	GUIDE TYPE	PRODUCT CODE	PART DESCRIPTION
	non-grooved door	wall or floor fix	1EG	expandable guide, nylon, blister pack suits doors 19 – 35mm
	non-grooved door	wall or floor fix	1EGA	expandable guide, aluminium, blister pack (with brush) suits doors 19 – 35mm
	grooved door	floor fix	1G	floor fixed groove guide, nylon, blister pack suits doors with 6 x 19mm groove
	grooved door	wall fix	1GW	wall fixed groove guide, nylon suits doors with 6 x 19mm groove
	floor channel	floor fix	9SLG	spring loaded guide drill 12.7 x 38mm hole

TRACK

PART	PRODUCT CODE	PART DESCRIPTION
	9TA20	2000mm aluminium track, mill
	9TA30	3000mm aluminium track, mill
	9TA40	4000mm aluminium track, mill
	9TA60	6000mm aluminium track, mill
	9TS09	915mm galvabond track
	9TS13	1255mm galvabond track
	9TS20	2000mm galvabond track
	9TS25	2500mm galvabond track
	9TS30	3000mm galvabond track
	9TS40	4000mm galvabond track
	9TS60	6000mm galvabond track

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OPTIONAL CHANNEL

PART	PRODUCT CODE	PART DESCRIPTION
	9GC20N	2000mm aluminium surface channel, natural anodised
	9GC30N	3000mm aluminium surface channel, natural anodised
	9GC40N	4000mm aluminium surface channel, natural anodised
	9GC60N	6000mm aluminium surface channel, natural anodised
	9GC20W	2000mm aluminium surface channel, white powdercoat
	9GC30W	3000mm aluminium surface channel, white powdercoat
	9GC40W	4000mm aluminium surface channel, white powdercoat
	9GC60W	6000mm aluminium surface channel, white powdercoat
	9GC20B	2000mm aluminium surface channel, brown powdercoat
	9GC30B	3000mm aluminium surface channel, brown powdercoat
	9GC40B	4000mm aluminium surface channel, brown powdercoat
	9GC60B	6000mm aluminium surface channel, brown powdercoat
	9FCA2N	2000mm aluminium rebate channel, natural anodised
	9FCA3N	3000mm aluminium rebate channel, natural anodised
	9FCA4N	4000mm aluminium rebate channel, natural anodised
	9FCA6N	6000mm aluminium rebate channel, natural anodised
	9FCA2W	2000mm aluminium rebate channel, white powdercoat
	9FCA3W	3000mm aluminium rebate channel, white powdercoat
	9FCA4W	4000mm aluminium rebate channel, white powdercoat
	9FCA6W	6000mm aluminium rebate channel, white powdercoat
	9FCA2B	2000mm aluminium rebate channel, brown powdercoat
	9FCA3B	3000mm aluminium rebate channel, brown powdercoat
	9FCA4B	4000mm aluminium rebate channel, brown powdercoat
	9FCA6B	6000mm aluminium rebate channel, brown powdercoat
	MWT4CA	4000mm aluminium tile channel, natural anodised

* Custom powdercoated or anodised available on request

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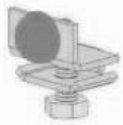
ACCESSORIES

PART	PRODUCT CODE	DESCRIPTION
	9JB	steel track, joining bracket, zinc Fitted to align steel tracks which are butted together, with carriers traversing the join.
	9AP	carrier adaptor plate for particle board doors Adaptor plate used to secure top carrier plate to particle board, chip-board or MDF.
	9TS	track stop, zinc Used to stop doors at end of track, or where two doors meet together on a single track.

INSTALLATION

FLOOR GUIDE

Installation using **wall / floor guide**

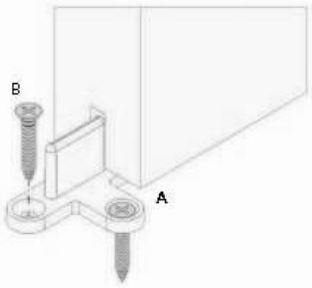
Separate top plate from carrier, fit top plate to door(s), feed carriers and stops into track, fit track, hang door(s), adjust carrier to align door, fit guide, adjust guide to remove excess play, locate and tighten stops.

Installation using 9SLG spring loaded guide

Separate top plate from carrier, fit top plate to door(s), fit bottom spring-loaded guide in each bottom corner of door rail, feed carriers and stops into track, fit track and channel, hang door(s), adjust carrier to align door, locate and tighten stops.

To fit 1G guide:

1 Fit screw A
2 Rotate guide sideways to remove excess play, then fit screw B.



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APPENDIX B

LIMIT SWITCH (HINGED ROLLER LEVER) DATASHEET

OMRON

Snap Action Switch
SS

Subminiature Snap Action Switch

- Economical, subminiature snap action switch offers long service life (30 million operations minimum)
- All models are free from overtravel restrictions, permit easy setting
- Wide switching capacity range from microvoltage/current loads (1 mA at 5 VDC to high-capacity loads 10.1 A at 250 VAC)
- Standard operating force, low force or super-low force models available
- RoHS Compliant

Ordering Information

■ Standard Type

Microvoltage/microcurrent load 0.1 A max. (Bifurcated crossbar contacts)

Actuator	Contact OF	Model				
		PCB terminal			Soldered terminal	Tab (#110) terminal
		Straight vertical	Parallel to left	Parallel to right		
Pin plunger	25 g	SS-01-ED	—	—	SS-01-E	SS-01-ET
	50 g	SS-01-FD	—	—	SS-01-F	SS-01-FT
	150 g	SS-01D	SS-01D1	SS-01D2	SS-01	SS-01T
Hinge lever	8 g	SS-01GL-ED	—	—	SS-01GL-E	SS-01GL-ET
	16 g	SS-01GL-FD	—	—	SS-01GL-F	SS-01GL-FT
	50 g	SS-01GLD	SS-01GLD1	SS-01GLD2	SS-01GL	SS-01GLT
Simulated roller lever	8 g	SS-01GL13-ED	—	—	SS-01GL13-E	SS-01GL13-ET
	16 g	SS-01GL13-FD	—	—	SS-01GL13-F	SS-01GL13-FT
	50 g	SS-01GL13D	—	—	SS-01GL13	SS-01GL13T
Formed hinge lever	8 g	—	—	—	SS-01GL14-E	SS-01GL14-ET
	16 g	SS-01GL14-FD	—	—	SS-01GL14-F	—
	50 g	SS-01GL14D	—	—	SS-01GL14	SS-01GL14T
Hinged roller lever	8 g	SS-01GL2-ED	—	—	SS-01GL2-E	SS-01GL2-ET
	16 g	SS-01GL2-FD	—	—	SS-01GL2-F	SS-01GL2-FT
	50 g	SS-01GL2D	—	—	SS-01GL2	SS-01GL2T

■ General-Purpose

5 A max. (Standard rivet contacts)

Actuator	Contact OF	Model				
		PCB terminal			Soldered terminal	Tab (#110) terminal
		Straight vertical	Parallel to left	Parallel to right		
Pin plunger	50 g	SS-5-FD	SS-5-FD1	SS-5-FD2	SS-5-F	SS-5-FT
	150 g	SS-5D	SS-5D1	SS-5D2	SS-5	SS-5T
Hinge lever	16 g	SS-5GL-FD	SS-5GL-FD1	SS-5GL-FD2	SS-5GL-F	SS-5GL-FT
	50 g	SS-5GLD	SS-5GLD1	SS-5GLD2	SS-5GL	SS-5GLT
Simulated roller lever	16 g	SS-5GL13-FD	—	SS-5GL13-FD2	SS-5GL13-F	SS-5GL13-FT
	50 g	SS-5GL13D	SS-5GL13D1	SS-5GL13D2	SS-5GL13	SS-5GL13T
Formed hinge lever	16 g	SS-5GL14-FD	SS-5GL14-FD1	—	SS-5GL14-F	SS-5GL14-FT
	50 g	SS-5GL14D	SS-5GL14D1	SS-5GL14D2	SS-5GL14	SS-5GL14T
Hinge roller lever	16 g	SS-5GL2-FD	SS-5GL2-FD1	SS-5GL2-FD2	SS-5GL2-F	SS-5GL2-FT
	50 g	SS-5GL2D	SS-5GL2D1	SS-5GL2D2	SS-5GL2	SS-5GL2T

10.1 A max. (Standard rivet contacts)

Actuator	Contact OF	Model				
		PCB terminal			Soldered terminal	Tab (#110) terminal
		Straight vertical	Parallel to left	Parallel to right		
Pin plunger	150 g	SS-10D	—	—	SS-10	SS-10T
Hinge lever	50 g	SS-10GLD	—	—	SS-10GL	SS-10GLT
Simulated roller lever	50 g	SS-10GL13D	—	—	SS-10GL13	SS-10GL13T
Formed hinge lever	50 g	—	—	—	SS-10GL14	—
Hinge roller lever	50 g	SS-10GL2D	—	—	SS-10GL2	SS-10GL2T

Specifications

■ Characteristics

Switch type		General-purpose
Operating speed (see note 3)		0.1 mm to 1 m/second (0.004 to 39.4 in/second)
Operating frequency	**Mechanical**	400 operations per minute (pin plunger actuator type)
	Electrical	60 operations per minute (pin plunger actuator type)
Insulation resistance		100 MΩ at 500 VDC
Dielectric strength	**Crossbar contact type**	600 VAC, 50/60 Hz for 1 minute (see note 1)
	Others	1,000 VAC, 50/60 Hz for 1 minute between terminals of same polarity 1,500 VAC, 50/60 Hz for 1 minute between current-carrying parts and ground and between each terminal and noncurrent-carrying metal parts
Vibration	**Malfunction durability**	10 to 55 Hz, 1.5 mm double amplitude
Shock	**Mechanical durability**	Low-OF type: 500 m/s^2 min. (approx. 50 g) Others: 1,000 m/s^2 min. (approx. 100 g)
	Malfunction durability	Standard type: 300 m/s^2 min. (approx. 30 g)
		Low-OF type: 200 m/s^2 min. (approx. 20 g)
		Lever type at TTP: Contact gap, 1 ms max.
Ambient temperature	**Operating**	-25° to 85° C with no icing
Humidity		85% RH max.
Service life	**Mechanical**	30 million operations minimum (OT: rated value) (see note 4)
	Electrical	200,000 operations minimum (rated load) (see note 2)
Weight		Approx. 1.6 g pin plunger type

Note: 1. SS-10 series only.
2. 50,000 operations minimum for the SS-10 series.
3. Applies to the pin plunger type (at the pin plunger of the lever type).
4. 10 million operations for the SS-10 series.
5. Data shown are of initial value.

■ Operating Characteristics

Characteristics	Part number				
	SS-01-E	SS-01-F SS-5-F	SS-01 SS-5	SS-10	SS-01GL-E
OF max.	25 g	50 g	150 g	150 g	8 g
RF min.	2 g	4 g	25 g	25 g	1 g
PT max.	0.5 mm (0.020 in)	0.5 mm (0.020 in)	0.5 mm (0.020 in)	0.6 mm (0.024 in)	1.2 mm (0.047 in)
OT min.	0.5 mm (0.020 in)	0.5 mm (0.020 in)	0.5 mm (0.020 in)	0.4 mm (0.016 in)	0.8 mm (0.032 in)
MD max.	0.1 mm (0.004 in)	0.1 mm (0.004 in)	0.1 mm (0.004 in)	0.12 mm (0.005 in)	13.6 mm (0.535 in)
OP	8.4 ± 0.5 mm (0.331 ± 0.020 in)	8.4 ± 0.5 mm (0.331 ± 0.020 in)	8.4 ± 0.5 mm (0.331 ± 0.020 in)	8.4 ± 0.5 mm (0.331 ± 0.020 in)	8.8 ± 0.8 mm (0.346 ± 0.032 in)

Characteristics	Part number				
	SS-01GL-F SS-5GL-F	SS-01GL SS-5GL	SS-10GL	SS-10GL13-E	SS-10GL13-F SS-5GL13-F
OF max.	16 g	50 g	50 g	8 g	16 g
RF min.	2 g	6 g	6 g	1 g	2 g
PT max.	1.2 mm (0.047 in)	1.2 mm (0.047 in)	1.0 mm (0.039 in)	1.2 mm (0.047 in)	1.2 mm (0.047 in)
OT min.	0.8 mm (0.032 in)	0.8 mm (0.032 in)	1.0 mm (0.039 in)	0.8 mm (0.032 in)	0.8 mm (0.032 in)
MD max.	13.6 mm (0.535 in)	13.6 mm (0.535 in)	13.6 mm (0.535 in)	15.5 mm (0.610 in)	15.5 mm (0.610 in)
OP	8.8±0.8 mm (0.346±0.032 in)	8.8±0.8 mm (0.346±0.032 in)	8.8±0.8 mm (0.346±0.032 in)	10.7±0.8 mm (0.421±0.032 in)	10.7±0.8 mm (0.421±0.032 in)

Characteristics	Part number				
	SS-01GL13 SS-5GL13	SS-10GL13	SS-01GL14-E	SS-01GL14-F SS-5GL14-F	SS-01GL14 SS-5GL14
OF max.	50 g	50 g	8 g	16 g	50 g
RF min.	6 g	6 g	1 g	2 g	6 g
PT max.	1.2 mm (0.047 in)	1.0 mm (0.039 in)	1.2 mm (0.047 in)	1.2 mm (0.047 in)	1.2 mm (0.047 in)
OT min.	0.8 mm (0.032 in)	1.0 mm (0.039 in)	0.8 mm (0.032 in)	0.8 mm (0.032 in)	0.8 mm (0.032 in)
MD max.	15.5 mm (0.610 in)	15.5 mm (0.610 in)	14.9 mm (0.587 in)	14.9 mm (0.587 in)	14.9 mm (0.587 in)
OP	10.7 ± 0.8 mm (0.421 ± 0.032 in)	10.7 ± 0.8 mm (0.421 ± 0.032 in)	10.1 ± 0.8 mm (0.398 ± 0.032 in)	10.1 ± 0.8 mm (0.398 ± 0.032 in)	10.1 ± 0.8 mm (0.398 ± 0.032 in)

Characteristics	Part number				
	SS-10GL14	SS-01GL2-E	SS-01GL2-F SS-5GL2-F	SS-01GL2 SS-5GL2	SS-10GL2
OF max.	50 g	8 g	16 g	50 g	50 g
RF min.	6 g	1 g	2 g	6 g	6 g
PT max.	1.0 mm (0.039 in)	1.2 mm (0.047 in)	1.2 mm (0.047 in)	1.2 mm (0.047 in)	1.0 mm (0.039 in)
OT min.	1.0 mm (0.039 in)	0.8 mm (0.032 in)	0.8 mm (0.032 in)	0.8 mm (0.032 in)	1.0 mm (0.039 in)
MD max.	14.9 mm (0.587 in)	19.3 mm (0.760 in)	19.3 mm (0.760 in)	19.3 mm (0.760 in)	19.3 mm (0.760 in)
OP	10.1 ± 0.8 mm (0.398 ± 0.032 in)	14.5 ± 0.8 mm (0.571 ± 0.032 in)	14.5 ± 0.8 mm (0.571 ± 0.032 in)	14.5 ± 0.8 mm (0.571 ± 0.032 in)	14.5 ± 0.8 mm (0.571 ± 0.032 in)

■ Ratings

Microvoltage/microcurrent load type

Contact form	General purpose/resistive load Bifurcated crossbar contacts	
	NC	NO
125 VAC	0.1 A	0.1 A
30 VDC	0.1 A	0.1 A
Inrush current	1 A max.	1 A max.

Standard type general purpose

	Rivet contacts									
	Resistive load				Lamp load		Inductive load		Motor load	
Switch series:	SS-5		SS-10		SS-5 and SS-10		SS-5 and SS-10		SS-5 and SS-10	
Contact form	NC	NO	NC	NO	NC	NO	NC	NO	NC	NO
125 VAC	5 A	5 A	10.1 A	10.1 A	1.5 A	0.7 A	3 A	3 A	2.5 A	1.3 A
250 VAC	3 A	3 A	10.1 A	10.1 A	1 A	0.5 A	2 A	2 A	1.5 A	0.8 A
8 VDC	5 A	5 A	10.1 A	10.1 A	2 A	2 A	5 A	4 A	3 A	3 A
14 VDC	5 A	5 A	10.1 A	10.1 A	2 A	2 A	4 A	4 A	3 A	3 A
30 VDC	4 A	4 A	4 A	4 A	2 A	2 A	3 A	3 A	3 A	3 A
125 VDC	0.4 A	0.4 A	0.4 A	0.4 A	0.05 A	0.05 A	0.4 A	0.4 A	0.05 A	0.05 A
250 VDC	0.2 A	0.2 A	0.2 A	0.2 A	0.03 A	0.03 A	0.2 A	0.2 A	0.03 A	0.03 A
Inrush current	20 A max.	10 A max.	20 A max.	15 A max. (both non-inductive and inductive loads)						

Note: 1. The above current ratings are the values of the steady-state current.

2. Inductive load has a power factor of 0.4 min. (AC) and a time constant of 7 milliseconds max. (DC). The inductive load applicable to the SS-10 series must have a power factor of 0.75 min.

3. Lamp load has an inrush current of 10 times the steady-state current

4. Motor load has an inrush current of 6 times the steady-state current.

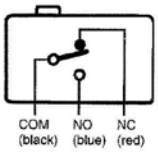
5. If the switch is used in a DC circuit and is subjected to inrush current or surge, connect a surge suppressor across the switch.

■ Contact Resistance (mΩ max., initial)

	SS-01□	SS-5□	SS-10□
Contact rating:	0.1 A	3 A or 5 A	10.1 A
Normal operating force models (SS-□)	50 mΩ	30 mΩ	30 mΩ
Low operating force models (SS-□-F)	100 mΩ	50 mΩ	—
Super-low operating force models (SS-□-E)	150 mΩ	—	—
Lead wire models (all OF types)	100 mΩ	50 mΩ	—

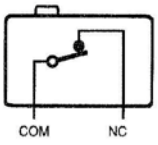
■ Contact Form

SPDT
(common throughout the series)

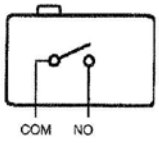


Sealed lead wire terminal models have color coded leads.

SPST-NC*
(standard models rated at 0.1 to 0.5 A)



SPST-NO*
(standard models rated at 0.1 to 5 A)



* Consult Omron for SPST-NC and SPST-NO contact form types ordering information.

■ Approvals

UL (File No. E41515), CSA (File No. LR21642), SS-5/SS-10: EN conforms 61058-1

Type		Rating
SS-10 series	General-purpose type	10.1 A, 250 VAC
SS-5 series	General-purpose type	5 A, 125 V, 3 A 250 VAC
SS-01 series	Super-low force type	0.1 A, 125 VAC, 30 VDC

VDE (File No. 5861-3221)

Type		Rating
SS-5 series	General-purpose type	5 A, 250 VAC

SEMKO (File Nos. 43-8614026/43-891609)

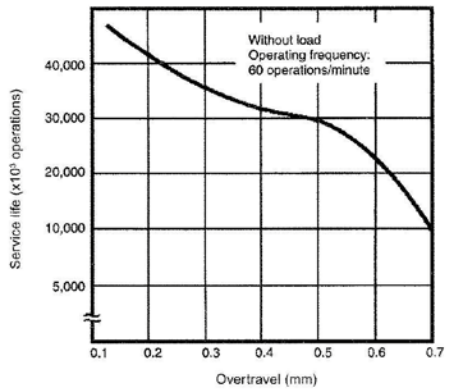
Type		Rating
SS-10 series	General-purpose type	10 A, 250 VAC
SS-5 series	General-purpose type	5 A, 250 VAC

Note: The rated values approved by each of the safety standards (e.g. UL, CSA) may be different from the performance characteristics individually defined in this catalog.

Engineering Data

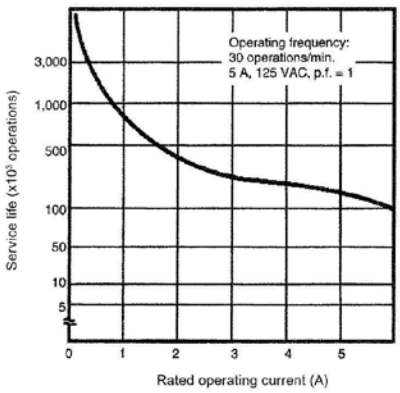
■ Mechanical service life

Standard type (SS-5, SS-10 series)



■ Electrical service life

Standard type (SS-5 series)

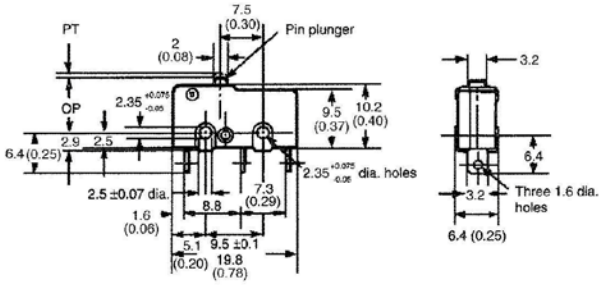


Dimensions

Unit: mm (inch)

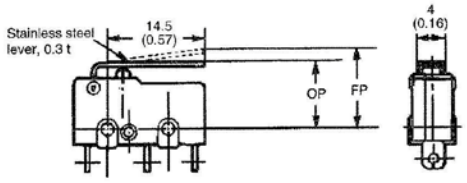
■ Pin Plunger

SS-01 (-E, -F)
SS-5 (-F)
SS-10



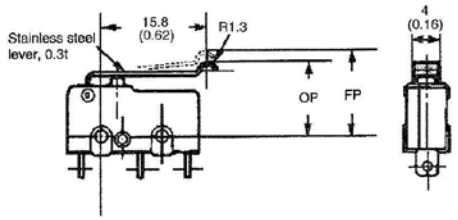
■ Hinge Lever

SS-01GL (-E, -F)
SS-5GL (-F)
SS-10GL



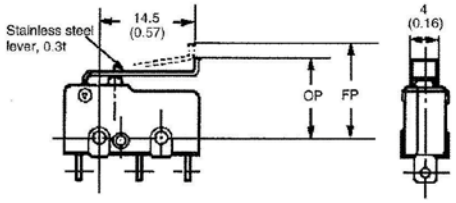
■ Simulated Roller Lever

SS-01GL13 (-E, -F)
SS-5GL13 (-F)
SS-10GL13



■ Formed Hinge Lever

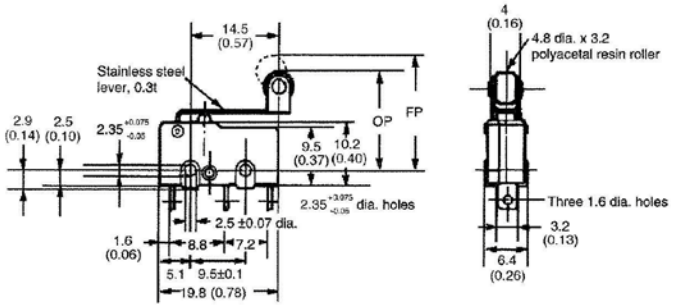
SS-01GL14 (-E, -F)
SS-5GL14 (-F)
SS-10GL14



Note: 1. Unless otherwise specified, a tolerance of ±0.4 mm applies to all dimensions.
2. Straight vertical PCB terminal models are shown above. Soldered terminal, Tab (#110) terminal, lead wire terminal, PCB terminal parallel to left and PCB terminal parallel to right are shown in the Terminals section.

■ Hinge Roller Lever

SS-01GL2 (-E, -F)
SS-5GL2 (-F)
SS-10GL2

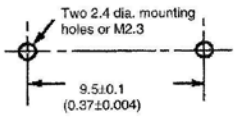


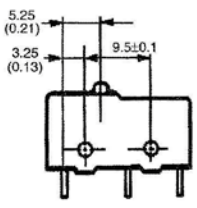
Note: Unless otherwise specified, a tolerance of ±0.4 mm applies to all dimensions.

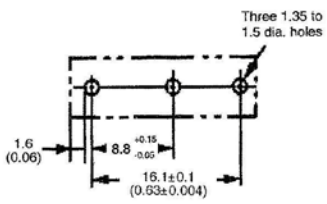
■ Mounting holes

Standard types

Mounting holes below are for reference only







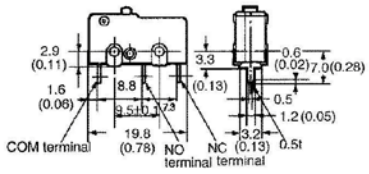
Note: Unless otherwise specified, a tolerance of ±0.4 mm applies to all dimensions.

Unit: mm (inch)

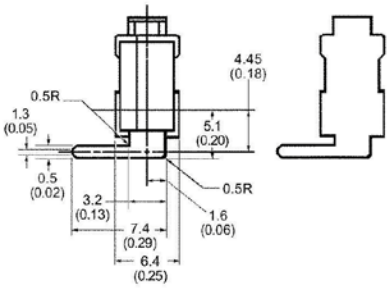
■ Terminals

General-Purpose Type

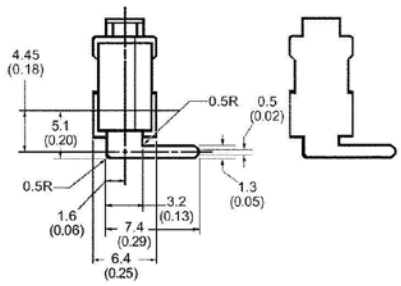
PCB terminal, straight vertical (D)



PCB terminal, parallel to left (D1)

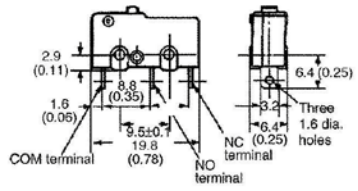


PCB terminal, parallel to right (D2)

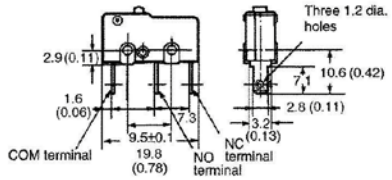


Note: Thickness of all the terminals is 0.5 mm.

Soldered terminal (blank)



Quick-connect tab (#110) terminal (T)



Omron Electronic Components, LLC

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1. Definitions: The words used herein are defined as follows.
   (a) Terms: These terms and conditions
   (b) Seller: Omron Electronic Components LLC and its subsidiaries
   (c) Buyer: The buyer of Products, including any end user in section III through VI
   (d) Products: Products and/or services of Seller
   (e) Including: Including without limitation
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9. Cancellation; Etc: Orders are not subject to rescheduling or cancellation unless Buyer indemnifies Seller fully against all costs or expenses arising in connection therewith.
10. Force Majeure: Seller shall not be liable for any delay or failure in delivery resulting from causes beyond its control, including earthquakes, fires, floods, strikes or other labor disputes, shortage of labor or materials, accidents to machinery, acts of sabotage, riots, delay in or lack of transportation or the requirements of any government authority.
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    (a) All sales and shipments of Products shall be FOB shipping point (unless otherwise stated in writing by Seller), at which point title to and all risk of loss of the Products shall pass from Seller to Buyer, provided that Seller shall retain a security interest in the Products until the full purchase price is paid by Buyer;
    (b) Delivery and shipping dates are estimates only; and
    (c) Seller will package Products as it deems proper for protection against normal handling and extra charges apply to special conditions.
12. Claims: Any claim by Buyer against Seller for shortage or damage to the Products occurring before delivery to the carrier must be presented in detail in writing to Seller within 30 days of receipt of shipment.

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   (b) Use in consumer Products or any use in significant quantities.
   (c) Energy control systems, combustion systems, railroad systems, aviation systems, medical equipment, amusement machines, vehicles, safety equipment, and installations subject to separate industry or government regulations.
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3. Prohibited Use: NEVER USE THE PRODUCT FOR AN APPLICATION INVOLVING SERIOUS RISK TO LIFE OR PROPERTY WITHOUT ENSURING THAT THE SYSTEM AS A WHOLE HAS BEEN DESIGNED TO ADDRESS THE RISKS, AND THAT THE PRODUCT IS PROPERLY RATED AND INSTALLED FOR THE INTENDED USE WITHIN THE OVERALL EQUIPMENT OR SYSTEM.
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1. Warranty: Seller's exclusive warranty is that the Products will be free from defects in materials and workmanship for a period of twelve months from the date of sale by Seller (or such other period expressed in writing by Seller). SELLER MAKES NO WARRANTY OR REPRESENTATION, EXPRESS OR IMPLIED, ABOUT ALL OTHER WARRANTIES, NON-INFRINGEMENT, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OF THE PRODUCTS.
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   (iii) Use in consumer products or any use in significant quantities.
   (iv) Systems, machines and equipment that could present a risk to life or property. Please know and observe all prohibitions of use applicable to this product.

   NEVER USE THE PRODUCT FOR AN APPLICATION INVOLVING SERIOUS RISK TO LIFE OR PROPERTY WITHOUT ENSURING THAT THE SYSTEM AS A WHOLE HAS BEEN DESIGNED TO ADDRESS THE RISKS, AND THAT THE OMRON PRODUCT IS PROPERLY RATED AND INSTALLED FOR THE INTENDED USE WITHIN THE OVERALL EQUIPMENT OR SYSTEM.
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ALL DIMENSIONS SHOWN ARE IN MILLIMETERS.
To convert millimeters into inches, multiply by 0.03937. To convert grams into ounces, multiply by 0.03527.

OMRON

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Cat. No. J01C-E-01 01/07 Specifications subject to change without notice Printed in USA

APPENDIX C

2N2222A NPN TRANSISTOR DATASHEET

Micro Commercial Components

Micro Commercial Components
20736 Marilla Street Chatsworth
CA 91311
Phone: (818) 701-4933
Fax: (818) 701-4939

2N2222
2N2222A

NPN Switching Transistors

Features

- High current (max.800mA)
- Low voltage (max.40V)
- Lead Free Finish/RoHS Compliant(Note 1) ("P" Suffix designates RoHS Compliant. See ordering information)

Maximum Ratings

Symbol	Rating		Rating	Unit
V_{CEO}	Collector-Emitter Voltage	2N2222 2N2222A	30 40	V
V_{CBO}	Collector-Base Voltage	2N2222 2N2222A	60 75	V
V_{EBO}	Emitter-Base Voltage	2N2222 2N2222A	5.0 6.0	V
I_C	Collector Current (DC)		800	mA
I_{CM}	Peak Collector Current		800	mA
I_{BM}	Peak Base Current		200	mA
T_J	Operating Junction Temperature		-55 to +150	°C
T_{STG}	Storage Temperature		-55 to +150	°C

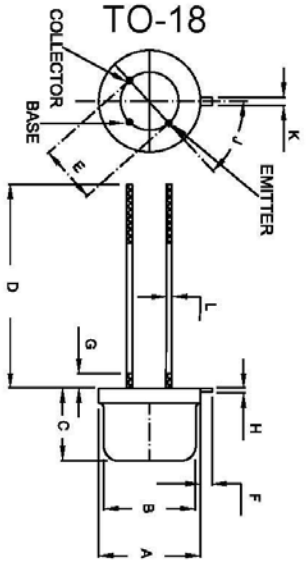
Thermal Characteristics

Symbol	Rating	Max	Unit
P_{tot}	Total power Dissipation $T_A \leq 25℃$ $T_C \leq 25℃$	 500 1.2	 mW W
R_{JC}	Thermal Resistance, Junction to Case	146	K/W
R_{JA}	Thermal Resistance, Junction to Ambient	350	K/W

Electrical Characteristics @ 25°C Unless Otherwise Specified

Symbol	Parameter		Min	Max	Units
OFF CHARACTERISTICS					
I_{CBO}	Collector cut-off current (V_{CB}=50Vdc, I_E=0) (V_{CB}=50Vdc, I_E=0,T_A=150℃) (V_{CB}=60Vdc, I_E=0) (V_{CB}=60Vdc, I_E=0,T_A=150℃)	2N2222 2N2222A 	 --- --- --- ---	 10 10 10 10	 nAdc uAdc nAdc uAdc
I_{EBO}	Emitter Cut-off current (I_C=0, V_{EB}=3Vdc)		---	10	nAdc
h_{FE}	DC Current Gain (I_C=0.1mAdc, V_{CE}=10Vdc) (I_C=1.0mAdc, V_{CE}=10Vdc) (I_C=10mAdc, V_{CE}=10Vdc) (I_C=150mAdc, V_{CE}=1.0Vdc)* (I_C=150mAdc, V_{CE}=10Vdc)*		 35 50 75 50 100	 300	
h_{FE}	DC Current Gain (I_C=500mAdc, V_{CE}=10Vdc) *	2N2222 2N2222A	30 40	--- ---	

Notes:1.High Temperature Solder Exemption Applied, see EU Directive Annex 7.



DIMENSIONS					
	INCHES		MM		
DIM	MIN	MAX	MIN	MAX	NOTE
A	.209	.230	5.309	5.842	Φ
B	.178	.195	4.521	4.953	Φ
C	.170	.210	4.318	5.334	
D	.50	----	12.7	----	
E	.100		2.54		ΦTYP
F	.028	.048	.7112	1.219	
G	-----	.050	-----	1.27	
H	.009	.031	0.229	0.787	
J	44°	46°	44°	46°	
K	.036	.046	0.914	1.168	
L	.016	.021	0.406	0.533	

Symbol	Parameter		Min	Max	Units
ON CHARACTERISTICS*					
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage8 (I_C=150mAdc, I_B=15mAdc) (I_C=500mAdc, I_B=50mAdc)	2N2222	--- ---	400 1.6	mVdc Vdc
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage* (I_C=150mAdc, I_B=15mAdc) (I_C=500mAdc, I_B=50mAdc)	2N2222A	--- ---	300 1.0	mVdc Vdc
$V_{BE(sat)}$	Base-Emitter Saturation Voltage * (I_C=150mAdc, I_B=15mAdc) (I_C=500mAdc, I_B=50mAdc)	2N2222	--- ---	1.3 2.6	Vdc Vdc
$V_{BE(sat)}$	Base-Emitter Saturation Voltage* (I_C=150mAdc, I_B=15mAdc) (I_C=500mAdc, I_B=50mAdc)	2N2222A	0.6 ---	1.2 2.0	Vdc Vdc
SMALL-SIGNAL CHARACTERISTICS					
C_{OB}	Output Capacitance (V_{CB}=10Vdc,I_E=ie=0, f=1.0MHz)		---	8.0	pF
f_T	TransitionFrequency (V_{CE}=20Vdc,I_C=20mAdc, f=100MHz)	2N2222 2N2222A	250 300	--- ---	MHz MHz
NF	Noise Figure (V_{CE}=5.0Vdc,I_C=200uAdc, Rs=2.0KOHM,f=1.0kHz,B=200Hz)	2N2222A	---	4.0	dB
SWITCHING CHARACTERISTICS					
T_d	Delay Time	I_{CON}=150mAdc, I_{BON}=15mAdc, $I_{B(off)}$=15mAdc	---	10	ns
t_r	Rise Time		---	25	ns
t_s	Storage Time		---	200	ns
t_f	Fall Time		---	60	ns

* Pulse Test: tp≤300us, Duty Cycle≤2.0%

Micro Commercial Components

Ordering Information

Device	Packing
(Part Number)-BP	Bulk;100pcs/Box

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APPENDIX D

SRUDH-SS112D1 SPDT RELAY DATASHEET

SRUDH series

12 Amp Miniature Power PC Board Relay

Appliances, HVAC, Office Machines

UL File No. E82292
CSA File No. LR48471
TUV File No. R60271

Users should thoroughly review the technical data before selecting a product part number. It is recommended that user also seek out the pertinent approvals files of the agencies/laboratories and review them to ensure the product meets the requirements for a given application.

Features

- Small package, 12 Amp switching capcity.
- 1 Form A and 1 Form C contact arrangements.
- Immersion cleanable, sealed version available.
- Applications include appliance, HVAC, security system, garage opener control, emergency lighting.

Contact Data @ 20°C

Arrangements: 1 Form A (SPST-NO) and 1 Form C (SPDT).
Material: Ag Alloy.
Max. Switching Rate: 300 ops./min. (no load).
30 ops./min. (rated load).
Expected Mechanical Life: 10 million operations (no load).
Expected Electrical Life: 100,000 operations (rated load).
Minimum Load: 100mA @ 5VDC.
Initial Contact Resistance: 100 milliohms @ 1A, 6VDC.

Contact Ratings

Ratings: 12A @ 120VAC resistive,
10A @ 240VAC resistive,
10A @ 28VDC resistive.

4A @ 120VAC inductive (cosø= 0.4),
4A @ 28VDC inductive (L/R=7msec)

Max. Switched Voltage: **AC:** 240V.
DC: 28V.
Max. Switched Current: 12A.
Max. Switched Power: 2,400VA, 300W.

Initial Dielectric Strength

Between Open Contacts: 750VAC 50/60 Hz. (1 minute).
Between Coil and Contacts: 1,500VAC 50/60 Hz. (1 minute).
Surge Voltage Between Coil and Contacts: 3,000V (1.2 / 50µs).

Initial Insulation Resistance

Between Mutually Insulated Elements: 1,000M ohms min. @ 500VDCM.

Coil Data

Voltage: 6 to 48VDC.
Nominal Power: 360 mW except 48VDC coil (510mW)
Coil Temperature Rise: 35°C max., at rated coil voltage.
Max. Coil Power: 130% of nominal.
Duty Cycle: Continuous.

Coil Data @ 20°C

SRUDH				
Rated Coil Voltage (VDC)	Nominal Current (mA)	Coil Resistance (ohms) ± 10%	Must Operate Voltage (VDC)	Must Release Voltage (VDC)
6	60	100	4.50	0.60
9	40	225	6.75	0.90
12	30	400	9.00	1.20
24	15	1,600	18.00	2.40
48	10	4,500	36.00	4.80

Operate Data

Must Operate Voltage: 75% of nominal voltage or less.
Must Release Voltage: 10% of nominal voltage or more.
Operate Time: 15 ms max.
Release Time: 5 ms max.

Environmental Data

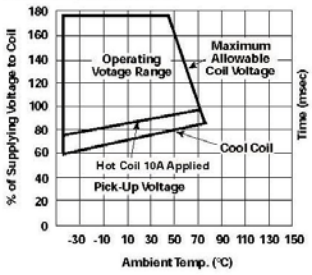
Temperature Range:
Operating: -30°C to +60°C
Vibration, Mechanical: 10 to 55 Hz., 1.5mm double amplitude
Operational: 10 to 55 Hz., 1.5mm double amplitude.
Shock, Mechanical: 1,000m/s² (100G approximately).
Operational: 100m/s² (10G approximately).
Operating Humidity: 20 to 85% RH. (Non-condensing).

Mechanical Data

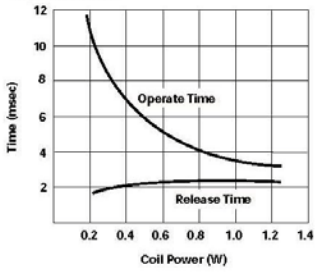
Termination: Printed circuit terminals.
Enclosure (94V-0 Flammability Ratings):
SRUDH-SS: Vented (Flux-tight) plastic cover
SRUDH-SH: Sealed plastic case
Weight: 0.42 oz (12g) approximately.

Reference Data

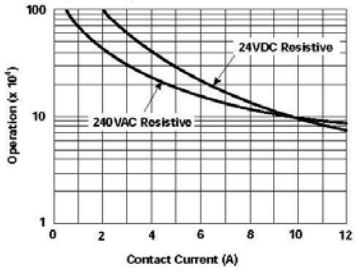
Coil Temperature Rise



Operate Time



Life Expectancy



Note: Rise data is based on the max. allowable temp. for E type insulation coil (115°C).

Ordering Information

Typical Part Number ►	SRUDH	-SS	-1	12	D	M	1	,000

1. Basic Series:
SRUDH = Miniature Power PC board relay.

2. Enclosure:
SS = Vent (Flux-tight)* plastic cover.
SH = Sealed, plastic case.

3. Termination:
1 = 1 pole

4. Coil Voltage:
06 = 6VDC 12 = 12VDC 48 = 48VDC
09 = 9VDC 24 = 24VDC

5. Coil Input:
D = Standard

6. Contact Arrangement:
Blank = 1 Form C, SPDT M = 1 Form A, SPST-NO

7. Contact Material:
1 = AgCdO

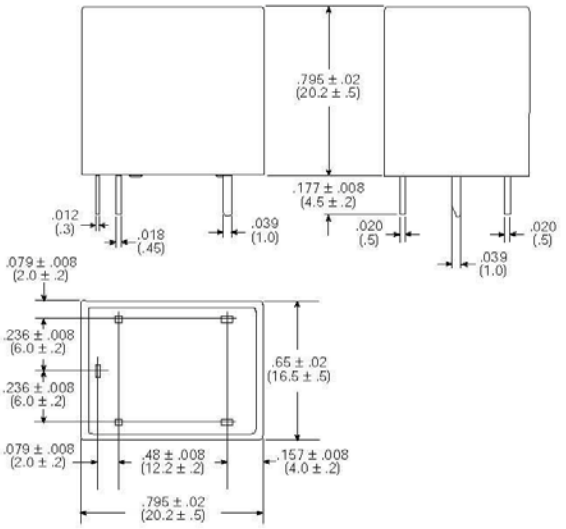
8. Suffix:
,000 = Standard model Other Suffix = Custom model

* Not suitable for immersion cleaning processes.

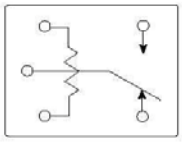
Our authorized distributors are more likely to maintain the following items in stock for immediate delivery.

SRUDH-SH-112D1,000 SRUDH-SH-112DM1,000
SRUDH-SH-124D1,000 SRUDH-SH-124DM1,000

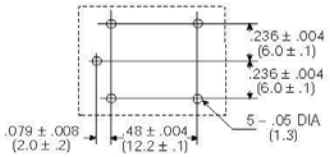
Outline Dimensions



Wiring Diagram (Bottom View)

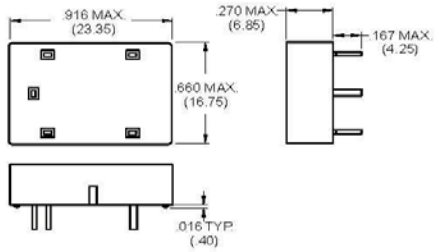


PC Board Layout (Bottom View)



Socket

27E1064 socket is rated 10A @ 300VAC. UL Recognized for US and Canada. Designed to fit same suggested board layout as relay.



Hold-Down Spring

20C430 spring is designed to secure SRUDH relay in 27E1064 socket.

APPENDIX E

1N4001 DIODE DATASHEET

FAIRCHILD
SEMICONDUCTOR®

1N4001 - 1N4007

Features

- Low forward voltage drop.
- High surge current capability.

DO-41
COLOR BAND DENOTES CATHODE

General Purpose Rectifiers (Glass Passivated)

Absolute Maximum Ratings*

T_A = 25°C unless otherwise noted

Symbol	Parameter	Value							Units
		4001	4002	4003	4004	4005	4006	4007	
V_{RRM}	Peak Repetitive Reverse Voltage	50	100	200	400	600	800	1000	V
$I_{F(AV)}$	Average Rectified Forward Current, .375" lead length @ T_A = 75°C	1.0							A
I_{FSM}	Non-repetitive Peak Forward Surge Current 8.3ms Single Half-Sine-Wave	30							A
T_{stg}	Storage Temperature Range	-55 to +175							°C
T_J	Operating Junction Temperature	-55 to +175							°C

* These ratings are limiting values above which the serviceability of any semiconductor device may be impaired.

Thermal Characteristics

Symbol	Parameter	Value	Units
P_D	Power Dissipation	3.0	W
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	50	°C/W

Electrical Characteristics

T_A = 25°C unless otherwise noted

Symbol	Parameter	Device							Units
		4001	4002	4003	4004	4005	4006	4007	
V_F	Forward Voltage @ 1.0 A	1.1							V
I_R	Maximum Full Load Reverse Current, Full Cycle T_A = 75°C	30							µA
I_R	Reverse Current @ rated V_R T_A = 25°C T_A = 100°C	5.0 500							µA µA
C_T	Total Capacitance V_R = 4.0 V, f = 1.0 MHz	15							pF

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General Purpose Rectifiers (Glass Passivated)
(continued)

Typical Characteristics

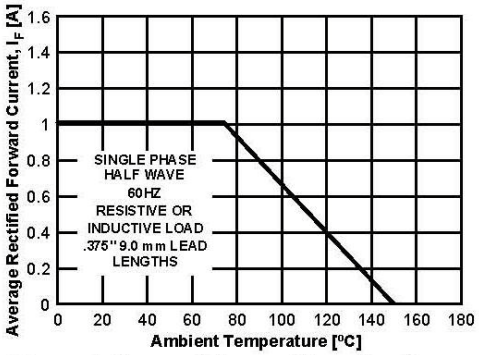

Figure 1. Forward Current Derating Curve

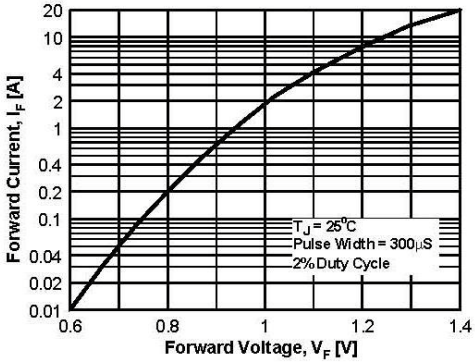

Figure 2. Forward Voltage Characteristics

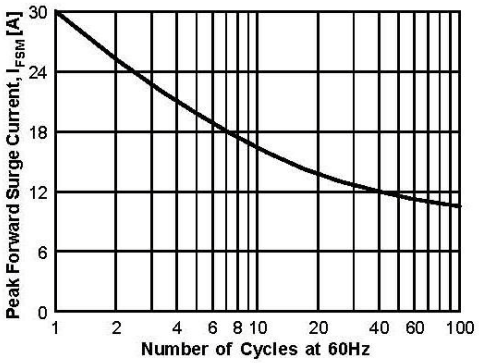

Figure 3. Non-Repetitive Surge Current

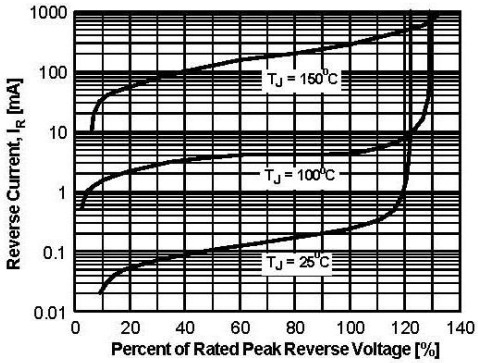

Figure 4. Reverse Current vs Reverse Voltage

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CROSSVOLT™	GlobalOptoisolator™	POP™	SuperSOT™-3	
DenseTrench™	GTO™	Power247™	SuperSOT™-6	
DOME™	HiSeC™	PowerTrench®	SuperSOT™-8	
EcoSPARK™	ISOPLANAR™	QFET™	SyncFET™	
E^2CMOS^{TM}	LittleFET™	QS™	TinyLogic™	
EnSigna™	MicroFET™	QT Optoelectronics™	TruTranslation™	
FACT™	MicroPak™	Quiet Series™	UHC™	
FACT Quiet Series™	MICROWIRE™	SILENT SWITCHER®	UltraFET®	

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

PRODUCT STATUS DEFINITIONS

Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

Rev. H4

APPENDIX F

PARALLEL PORT

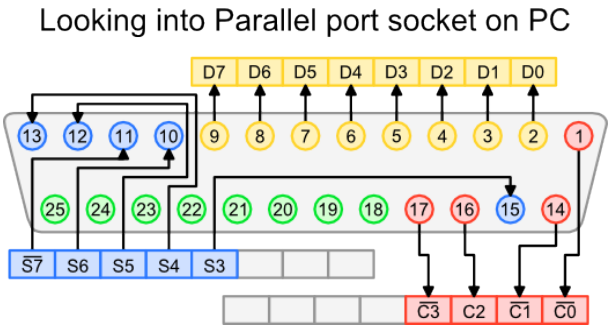


Figure of the Parallel port

Data port (yellow) is simply used for outputting data on the parallel port's data lines. This register is normally a write only port. When the CPU wants to transmit data to the printer, it writes eight bits into the data port latch. The latch output as stated in the table above is labelled D0-D7. D0 is the least significant bit and D7 is the most significant bit. The data signal will transfer print data strobe to instruct the printer that new printer is available.

The **status port** (blue) is a read-only port. Any data written to it will be ignored. This port provides the printer adapter with the facility to read the status of the printer through various signals. The status port signals have the following functions:

4. Busy – it indicates that the printer is busy and cannot take more data

5. nACK – it indicates the acknowledgement from the printer that data is received
6. Paper Out – a signal that the printer generates that there is no paper in the printer
7. Select – this signal indicates that the printer is enabled
8. nERROR – this signal indicates error condition on the printer

The **control port** (red) of the adapter provides the necessary control signals to the printer. This port was intended as a write-only port. When a printer is attached to the parallel port, four controls are used. All These four controls are as follows:

9. nSTROBE – this control is to instruct the printer that new data is available
10. nAuto-Linefeed – it instructs the printer to automatically insert a line feed for each carriage return
11. Reset/nINIT – this control is used to reset the printer
12. nSelect Input – it is used to indicate to the printer that it is selected

Note: The 4-bit output port can be configured as a 4-bit input port.

All 17 lines are accessible under program control and can be used for TTL signal level data transfer in to and out of the PC. One benefit of the parallel port

is that the IEEE has continued to improve the parallel port specification while at the same time retaining backward compatibility with the original parallel port.

Source: Programming the Parallel Port: Interfacing the PC for Data Acquisition and Process Control by Dhananjay V. Gandre

APPENDIX G

AUTOMATIC WHITEBOARD ERASER QUICK USER'S GUIDE

Safety Instructions

1. Always read the safety instructions carefully.
2. Keep this User's Manual for future reference.
3. Place the power cord such a way that people cannot step on it. Do not place anything over the power cord.
4. Never pour any liquid into any openings that could damage or cause electrical shock.
5. If any of the following situations arises, get the equipment checked by a service personnel:
    - The power cord or plug is damaged.
    - Liquid has penetrated into the equipment.
    - The equipment has not worked well or you cannot get it work according to User's Manual.
    - The equipment has dropped or damaged.
    - The equipment has obvious sign of breakage.

Getting Started

Equipment Specifications

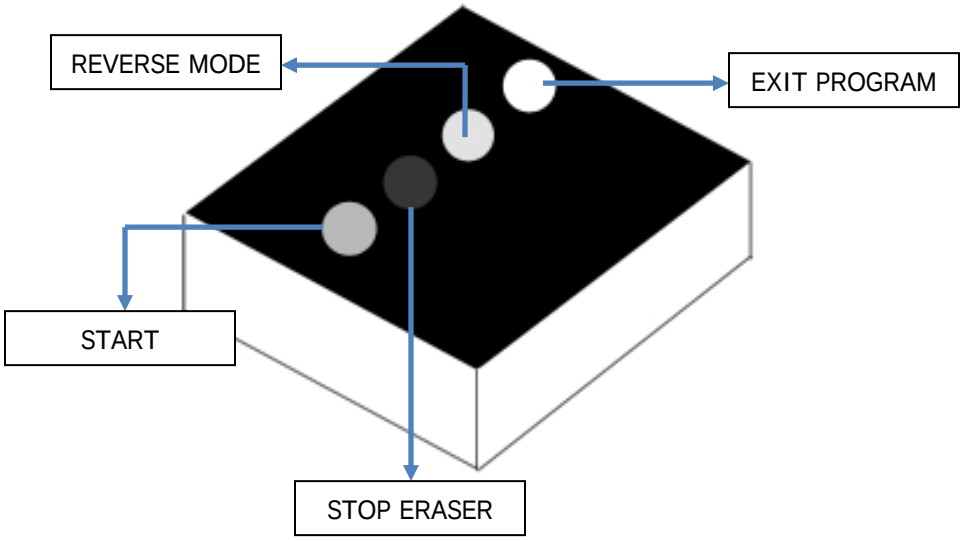
Port	- One 25 pin parallel port
Programming Language	- Assembly Language
Motor	- Two 12 volt DC bi-directional motors
Indicators	- Eight LEDs
Board	- 35” x 24” whiteboard
Eraser	- 3M Erasing Pad
Frame and Stand	- Counter trim and angled aluminium bars

Hardware Setup

This part provides you with the information about hardware setup procedures. While doing the installation, be careful in holding the components and follow the installation procedures. For some components, if you install in the wrong orientation, the components will not work properly.

Procedures for setting up and operation of the Automatic Whiteboard Eraser:

1. Make sure that the parallel cord of the equipment is securely connected to the computer's parallel port and the equipment's power cord in securely connected to an outlet.
2. Check if the frame of the eraser is on the left side of the board and not touching the limit switch located at the back of the whiteboard.
3. Power on the computer on which the equipment is connected to.
4. Ensure that the computer is working properly before running the program.
5. Double-click the **step1** icon on the desktop.
6. In the command prompt, type the shortcut **initialize**. This keyword goes to the location of the application needed to run the prototype.
7. On the command line, type **design2.exe**.



8. Once the white button is pressed, type **exit** on the command line to end the Command prompt session.
9. To turn off the equipment, make sure that the program has been terminated before disconnecting the parallel port and the power cord.

   Note: Check if the frame of the eraser is in its normal orientation which is in the left side of the whiteboard.

Replacing the eraser:

1. Unscrew the eraser holder.
2. Cut 1” thick of the 3M Erasing Pad and insert it to the eraser holder.
3. Screw the eraser holder back to the support.